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# A STUDY OF EVOLUTIONARY TRENDS IN ENGINEERING CURRICULA *

## PART I. SCOPE AND METHODS

**Purposes and Auspices.**—The fact-finding studies included in the present investigation are concerned almost wholly with the present state of engineering education. As a constantly developing process, engineering education cannot be pictured adequately or appraised rightly if presented in static terms alone, but rather needs to be viewed in an evolutionary perspective. The present study traces the trend of evolution in five major engineering curricula in order that their present state may be defined in terms of direction as well as position. These studies have been carried out by the Staff of the investigation, with valuable assistance from the United States Bureau of Education in supplying documentary sources.

**Scope.**—To represent the general trends throughout the entire group of colleges, ten were chosen which afford a reasonable diversity of origins, status and location, namely: Alabama Polytechnic Institute, Case, Cornell, Illinois, Iowa State College, Lehigh, Massachusetts Institute of Technology, Michigan, Purdue and Wisconsin. Two of these are independent polytechnic institutes; one is an independent university with associated land grant and state-aided colleges; one is an independent university in which engineering holds a dominant position; two are state universities including land grant colleges; three are typical detached land grant institutions; and one a state university without land grant colleges. One is in New England, two in the middle Atlantic states, one in the South, three in the Great Lakes area, and three in the Mississippi valley. The choice of these institutions was also influenced by such practical considerations as the availability of

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catalogs issued in or near the years of reference, the presentation of curricula in a form that lends itself to quantitative analysis, and the undergraduate nature of the curricula. The group chosen, taken as a whole, is fairly representative of the dominant influences in engineering education during the period of the study.

Curricula in civil, mining, mechanical, electrical and chemical engineering are included in the analyses. With slight deviations in the actual year in a few cases, these curricula have been analyzed as of 1870–71, 1885–86, 1900–01, 1915–16 and 1923–24. Curricula in electrical engineering appear first in the analyses for 1885 and curricula in chemical engineering first in 1900. The cases actually covered by the several analyses are shown in Table 1 on page 583.

**Classification of Subjects.**—It may be noted that a total of 161 complete curricula have been analyzed. To bring this study within reasonable bounds of time and cost, it was necessary to reduce the method to a series of simple clerical operations. The first step was to classify the subject matter into a limited number of significant groups. It was found that thirteen groups could be made to include all the items of the several curricula with only infrequent and slight accommodations. These groups are as follows: (1) The principal branch of engineering which gives its name to the curriculum; (2) other specific engineering subjects; (3) mechanics and hydraulics; (4) graphics, *i.e.*, drawing, descriptive geometry, etc.; (5) shop work; (6) free electives; (7) physical and natural sciences; (8) mathematics; (9) economics; (10) other social studies, principally history and political science; (11) English; (12) foreign languages; and (13) physical and military training, including hygiene. Restricted electives were divided equally between the subjects from which a choice was permitted. Most of the discretionary cases involved a choice between graphics, mechanics and hydraulics, and the two groups of specific engineering subjects. In each such instance the classification was based on the catalog description of the item in question. In some cases it was necessary to make certain arbitrary classifications; for example, chemistry

taught in the first two years of the chemical engineering curriculum was classed under physical science and that given in the last two years under the principal branch of engineering. Astronomy, geology and mineralogy were classified under physical science in all cases. In the main the classifications of individual curricula contain few doubtful items and the composite results are involved in relatively little uncertainty from this source.

**Choice of a Unit.**—In order to combine the curricula of the ten institutions into a series of composite pictures from which general trends rather than local variations might be inferred, it was necessary to express the content of each subject group in some uniform quantitative unit. Both the past and the present methods of expressing time requirements and evaluating academic credits are so diverse that it seemed necessary to adopt a relative, rather than an absolute, unit. These difficulties were reduced to a minimum by employing as the unit the "normal academic year," representing the total requirements set by an institution for a period of from eight to nine months of approximately continuous work. Wherever summer courses in residence are required, these were counted as an additional requirement and raised the total for the entire curriculum proportionately above the nominal value of four "years." The use of the "academic year" as a unit of measure leaves out of account all variations, other than required summer terms, between the quantitative requirements of different institutions, of different years of the course, and of different years of reference.

**Quantitative Treatment.**—After the subjects had been classified the items were rated according to the specified time allotment or assigned credit value. Where credit values were not expressly stated, the usual rating gave equal values to one hour of class instruction requiring preparation, two hours of practical exercises on which written reports are required, and three hours of practical exercises complete in themselves. Each item was expressed as a percentage of the total requirements of the year in which it occurred. Totals for each of the thirteen subject groups in the complete curriculum were

then computed and expressed in units and fractions of a complete academic year. The requirements of the several institutions for a like year in a given curriculum were then averaged to obtain a composite picture. Finally, a synthesis of all the curricula of each given period was made by weighting the averages in accordance with the number of cases under each curriculum title, so that the most general trends might be made evident. The composite results referred to above are given in Tables 2 and 4, on pages 584 and 585.

## PART II. DISCUSSION AND GRAPHICAL PRESENTATION OF THE RESULTS

**Evolutionary Trends in Curricula.**—The first series of charts, Figs. 1 to 5 inclusive, shows the trend of evolution in particular curricula, as analyzed into thirteen subject groups, and Fig. 6 shows the generalized trend, based on the composite of the five curricula examined. The arrangement of the subject groups in each of these diagrams is in the order of increasing specialization, from the bottom upward. A horizontal reference line marked by a zero at the margin is placed at the middle of each diagram. The subject groups which are common to both engineering and general academic education are ranged below this line, while the distinctive technical subjects of engineering, together with the free electives, are ranged above. But for the element of confusion which would result, it would be appropriate to divide the block representing free electives equally above and below the reference line. The arrangement of the chart makes a trend toward increasing specialization directly apparent as an upward displacement of successive bands, and a tendency toward greater concentration on the major branch of engineering is shown by a lengthening of the topmost block. The arrangement of the free electives tends to exaggerate somewhat the indication of specialization. The blocks are shown alternately black and shaded merely to distinguish them more boldly.

It is apparent that the general trend since 1870 has been toward greater specialization and concentration, but there

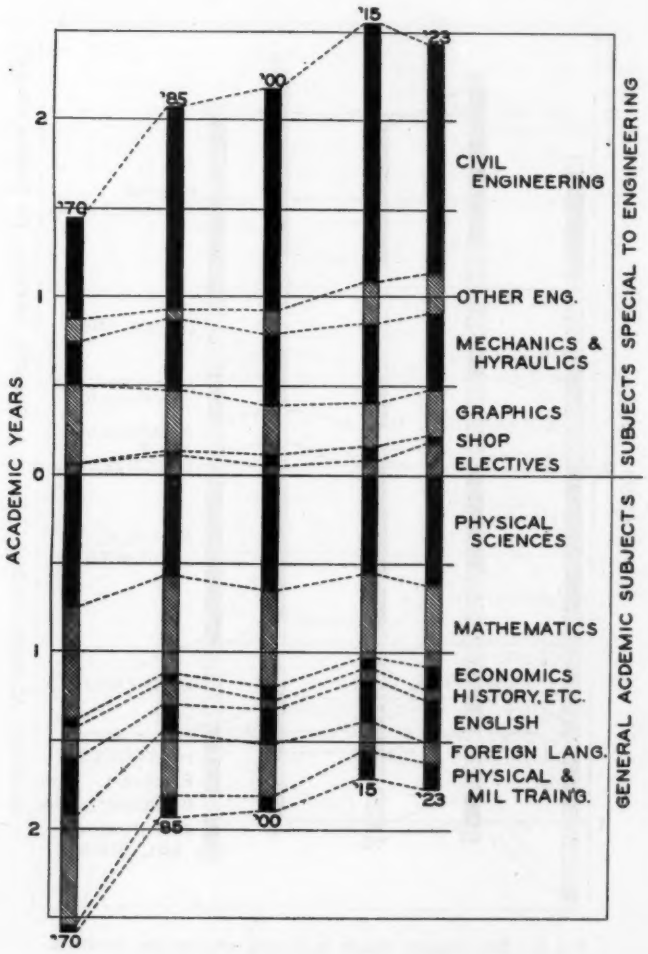


Fig. 1. Evolutionary trends in civil engineering curricula.

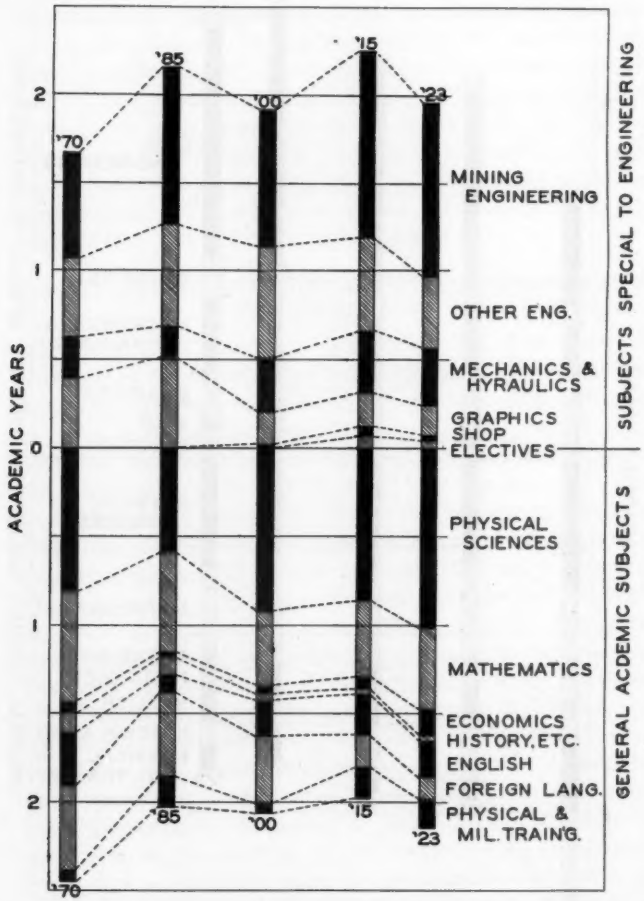


FIG. 2. Evolutionary trends in mining engineering curricula.

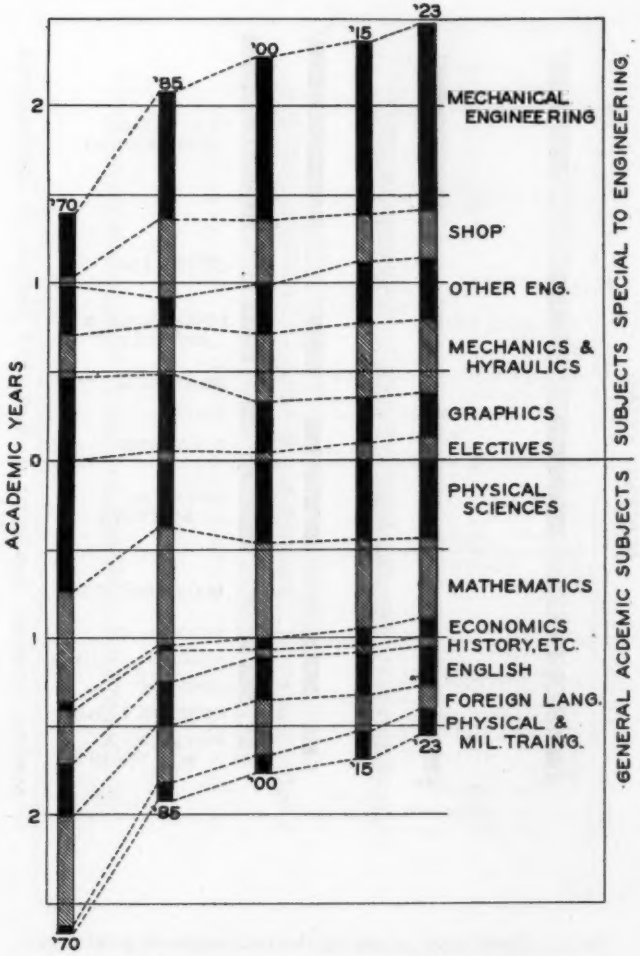


FIG. 3. Evolutionary trends in mechanical engineering curricula.

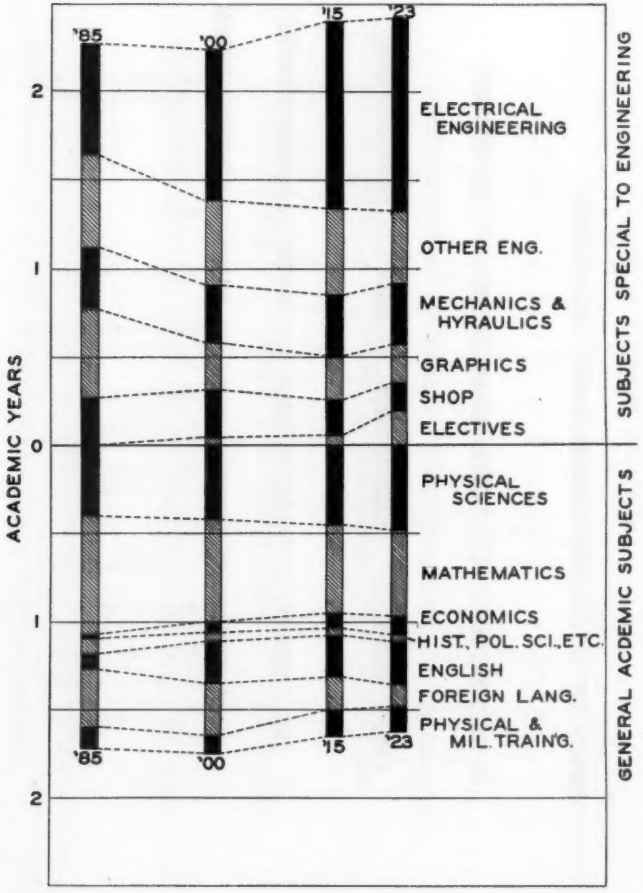


FIG. 4. Evolutionary trends in electrical engineering curricula.

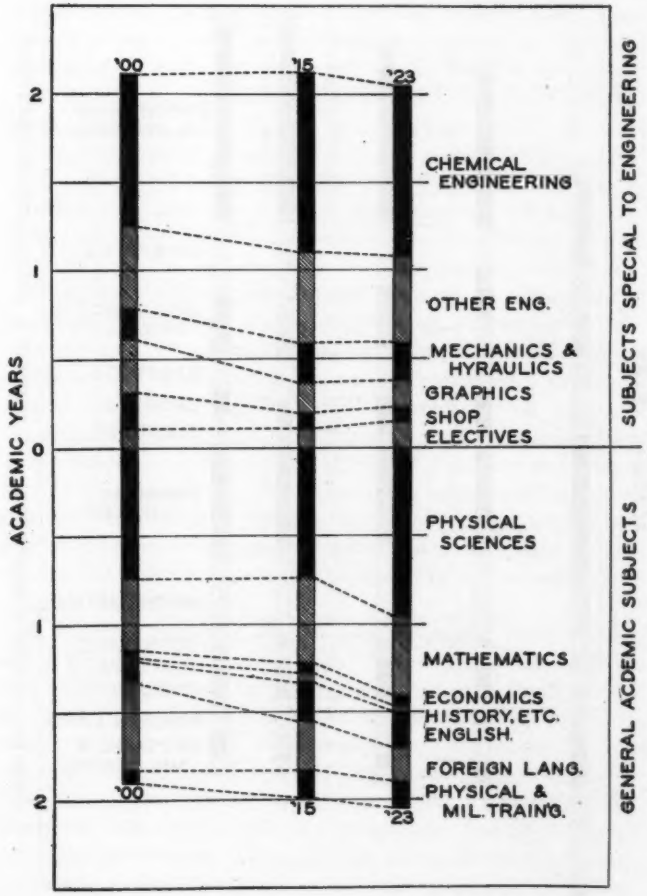


FIG. 5. Evolutionary trends in chemical engineering curricula.

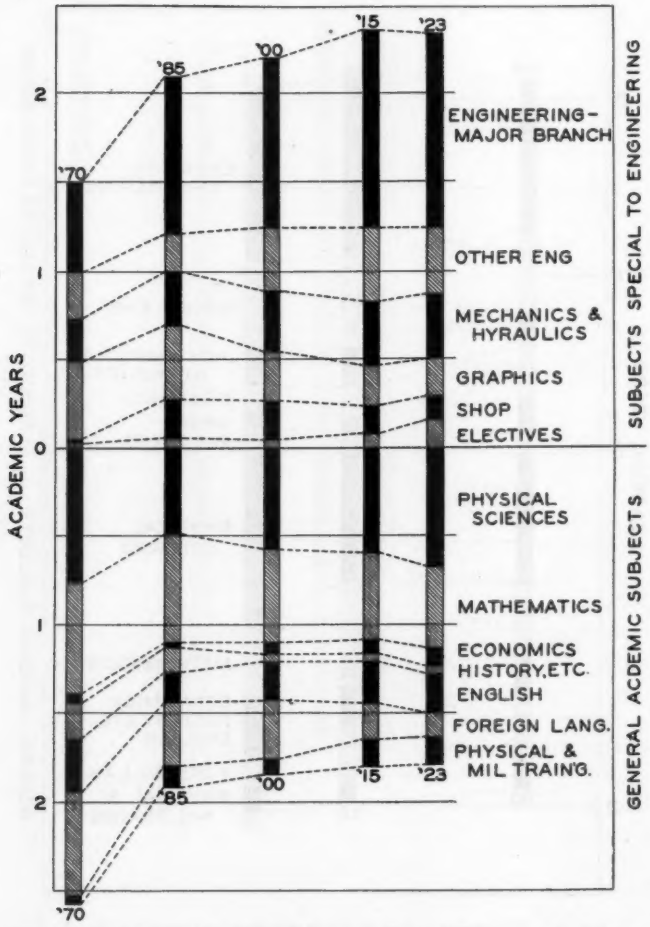


FIG. 6. Evolutionary trends in the composite of all the curricula studied.

are indications that this movement has passed its peak and that a reaction to more general training is developing. Attempts to popularize undifferentiated curricula in "general engineering" have not prospered in the face of this movement toward specialization. Undoubtedly the desires of students, teachers, practitioners and employers have all contributed in some measure to the rise of specialization, as well as the great expansion of engineering knowledge, and it is significant to note the turn of contemporary opinion away from early and extensive specialization for undergraduate students.[1]

**Evolution in Particular Subject Groups.**—A second series of charts portrays the evolutionary trends in particular subject groups. The identity and magnitude of the requirements in the several curricula are indicated by a group of distinct bands with abbreviated designations. A common base line is used for two subject groups in a number of cases where the sums of the two sets of related items are significant. In Fig. 10, which deals with the specific subjects in engineering, the item of shop work is added above the mechanical engineering subjects proper to give a more adequate indication of the relative degree of concentration in the mechanical engineering curriculum.

A striking reduction in the total linguistic requirements since 1870 is indicated in Fig. 7. The requirements in *English* quickly fell away from the generous quota of early years under the pressure of the fast-rising technical requirements, then recovered strength, became stabilized, and made slow advances. The *foreign languages* have made a steadily losing fight for recognition over the entire period. As pointed out elsewhere this decline reflects a progressive loss of their tool value as the English language has advanced to its present dominating position in scientific and technical literature. The battle for the continued existence of foreign languages as a requirement will probably be fought largely on the ground of their cultural, commercial and political values, and it is a question whether this issue has yet been seriously faced.

[1] See Bulletin No. 9 of this series.

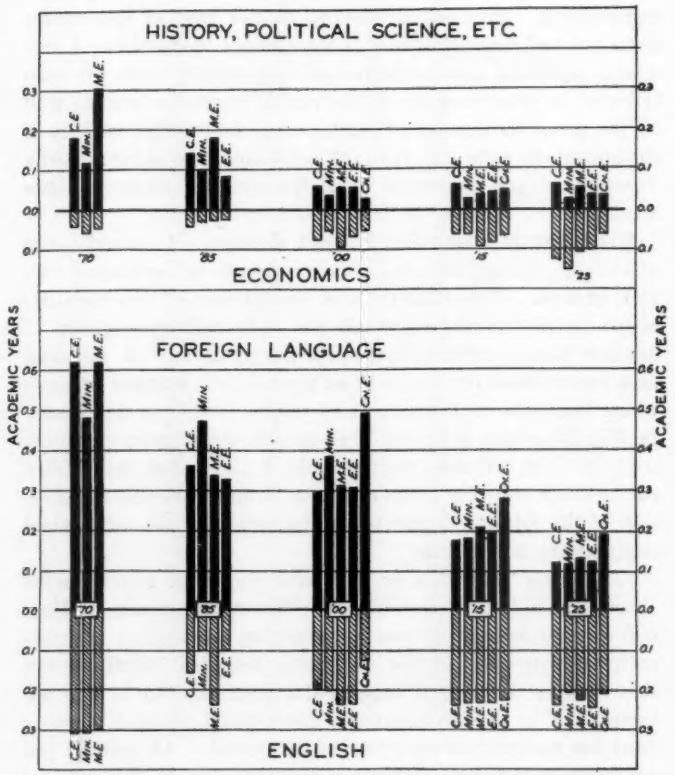


FIG. 7. Changes in social and language studies in engineering curricula.

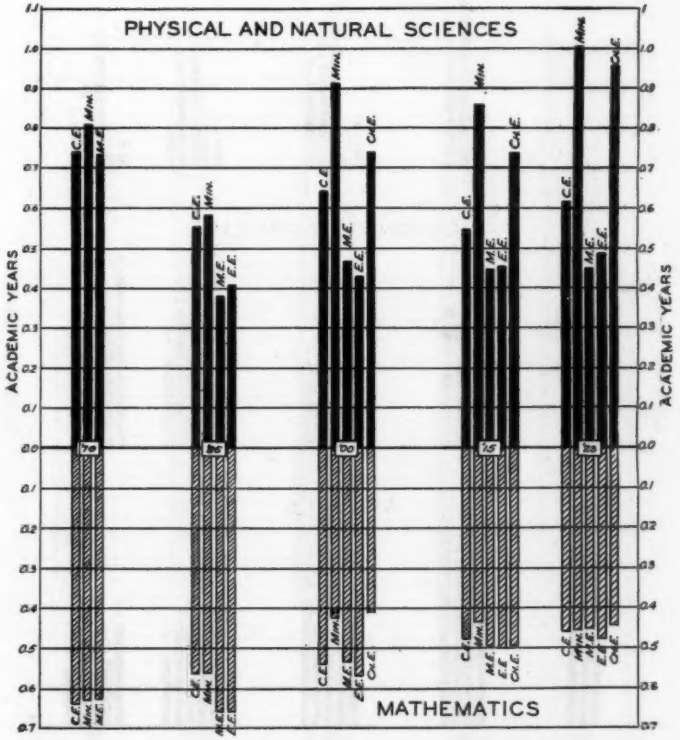


FIG. 8. Changes in requirements in mathematics and physical sciences.

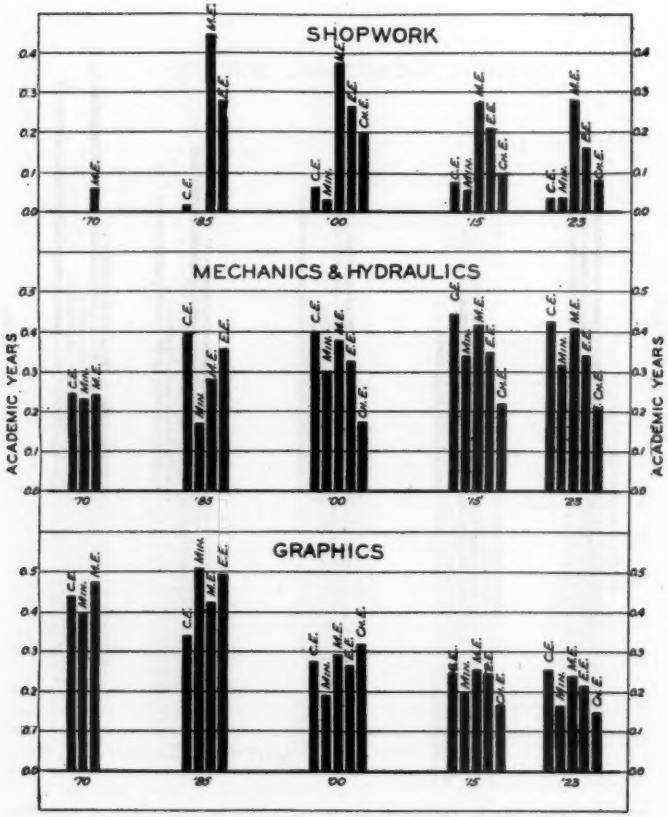


FIG. 9. Changes in requirements in general technical subjects.

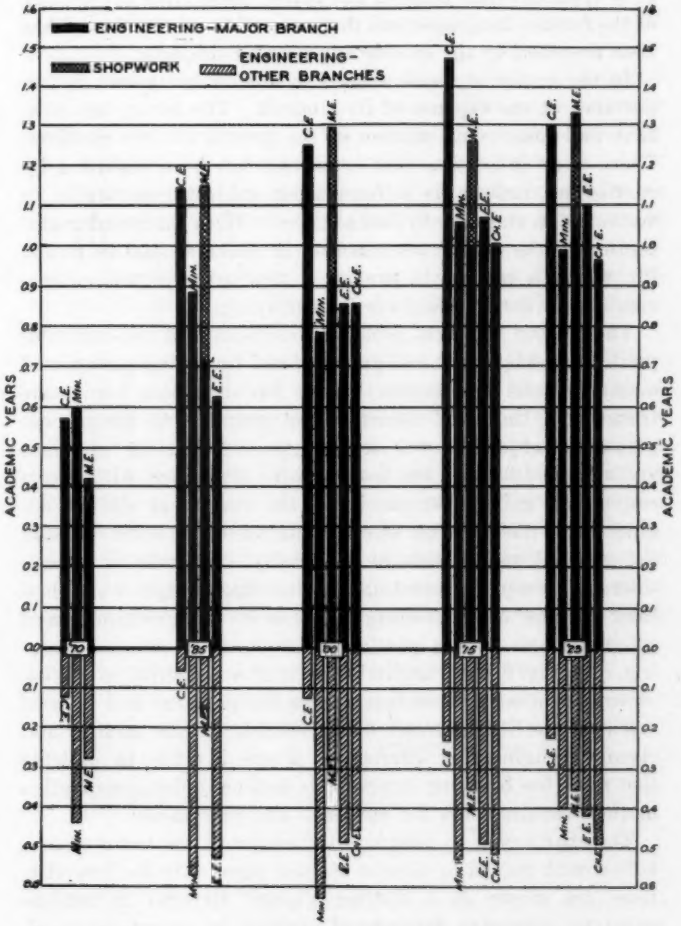


FIG. 10. Changes in requirements in specific engineering subjects.

It is apparent that English has gained little from the decline of the foreign languages and that most of the time released has been absorbed by the specific engineering subjects.

In the group of *social studies* economics has grown in importance at the expense of its kindred. The latter, however, have had some compensation in the growth of free electives. There is no indication that economics has been regarded by curriculum makers as a foundation subject comparable to mathematics and the physical sciences. With the broader conception of the engineer's function in industry and in public life which is coming to prevail, a new attitude toward economics and derived subjects is developing.

The *general technical groups* give evidence of the declining position of shop work and graphics and the rising strength of mechanics and hydraulics. There has doubtless been some transfer of time and content from graphics to specific engineering subjects, but it seems apparent that the emphasis given to manual arts has been steadily declining, with a corresponding gain in emphasis on the analytical side of engineering. This change of emphasis reflects in some measure the gradual assimilation to university standards of a considerable group of present-day engineering colleges which had their origins as semi-collegiate schools of agriculture and mechanic arts giving particular emphasis to manual training. In Fig. 8 there are indications of a reduction in *mathematical content* and an increase in the *physical* and *natural sciences*, the latter trend being notable in the mining and chemical engineering curricula. There is little to indicate that there has been any appreciable decline in the gross mathematical requirements for entrance and graduation.

The charts give no adequate indication of the trend of evolution with regard to *elective studies*, since only the free electives are shown as a distinct group. General indications point to increasing latitude of election in recent years, although engineering curricula in general remain largely on a prescribed basis. One of the striking features of this series of figures is the increasing degree of concentration on *specific technical subjects* up to 1915, as indicated in Fig. 10. Shop

work is shown as a supplementary item to specific subjects in mechanical engineering in order more fully to bring out such concentration in that curriculum.

**Are the Data Representative?**—It should be understood that this is a study of the curricula of ten representative institutions, rather than a study of the ten most representative or influential models in each field of engineering. It is true, however, that the group of institutions chosen is of more than average prominence and strength and that a number of them have exercised a strong influence over the younger colleges. Possibly the cases chosen represent the dominant influences in mining engineering education somewhat less adequately than in the other fields.

An objective check on the degree to which the data of this study are representative of the general state may be had by comparing certain items from this study with the average results for the country at large as set forth in the comprehensive survey by Dr. W. C. John of the United States Bureau of Education, Bulletin No. 10 of this series. Significant items from the two studies are shown side by side in the following table. The value given in each case represents the percentage of the entire requirements of the curriculum under the given head, in the average case in 1923–24. The columns which

COMPARISONS OF AVERAGE TIME ALLOTMENTS IN 1923–24

(All items are percentages)

| Subject Groups | Engineering Curriculum | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Civil | | Mining | | Mechanical | | Electrical | | Chemical | |
| | (A) | (B) | (A) | (B) | (A) | (B) | (A) | (B) | (A) | (B) |
| Engineering, major branch. | 31.1 | 29.9 | 24.2 | 23.9 | 26.4 | 29.6 | 27.2 | 24.5 | 23.7 | 26.2 |
| Total required engineering. | 53.4 | 55.9 | 46.8 | 48.7 | 58.0 | 57.7 | 55.2 | 56.7 | 46.3 | 50.6 |
| Mathematics | 10.9 | 11.9 | 11.1 | 10.8 | 11.1 | 12.1 | 11.9 | 12.3 | 10.8 | 11.7 |
| Physical sciences | 14.6 | 15.4 | 25.0 | 25.6 | 11.0 | 13.6 | 12.0 | 14.0 | 23.4 | 20.6 |
| Social sciences | 4.5 | 3.3 | 4.4 | 3.1 | 4.0 | 3.4 | 3.5 | 3.7 | 2.5 | 2.7 |
| English | 5.6 | 6.2 | 5.1 | 5.2 | 5.5 | 6.2 | 6.1 | 6.1 | 4.9 | 2.8 |
| Foreign languages | 2.9 | 1.8 | 2.9 | 1.2 | 3.3 | 1.4 | 3.0 | 1.9 | 4.8 | 2.8 |
| Physical and military training | 3.5 | 3.7 | 3.8 | 3.6 | 3.6 | 4.1 | 3.6 | 3.6 | 3.8 | 3.3 |

relate to the present study are headed by an (*A*) and those based on the studies of the Bureau of Education by a (*B*). Allowing for the fact that the two analyses were made independently, with possibilities of minor differences in classification and in weighting the time allotments, and that elective items were handled differently, the two sets of data are in substantial conformity. The greatest relative disparity is in the foreign language requirements. Apparently the institutions covered by this study are more generous toward this division of work than engineering colleges in general. Probably their entrance requirements are somewhat above the average, as indicated by the lower requirements in mathematics in their curricula. On the whole it seems to be a fair inference that, if present conditions may be taken as an index of what has existed in the past, the data of this study may be accepted as reasonably representative of conditions in general.

**Limitations of the Analyses.**—The method of analysis employed has two important limitations; it gives no indication of the increase in the total requirements in engineering curricula between 1870 and 1923; and it affords no basis for the comparison of the volume of requirements in engineering and non-engineering curricula.

**Total Requirements of 1870 and of Today.**—The measurement of requirements for entrance and for graduation in credit units is a relatively recent innovation. Comparatively few college catalogs of the period from 1870 to 1875 give data which can be translated into such units with reasonable certainty, but such comparisons as can be made indicate that the arts curricula of that period represented from 120 to 128 semester-hours, as at present. In some institutions, e.g., Lehigh, equal requirements were set in engineering, while in some others, e.g., Wisconsin, the practical exercises in field work and drawing represented an increment to the usual quota of academic work. The evidence indicates that the total requirements in arts curricula have remained sensibly constant, but that a steadily increasing load was introduced into engineering curricula up to about 1900 and that there

has been a slight easing up since that time. The engineering curricula of today, as analyzed by Dr. W. C. John in Bulletin No. 10 of this series, represent a median requirement of close to 145 semester-hours. All facts considered, it would seem safe to infer that the total requirements included in an engineering curriculum of four years have risen fifteen to twenty per cent, on the average, in the period covered by this study.

From the nature of the entrance requirements of 1870, it would seem that practically one year less of preparation, on the average, was required then than now. The required subjects were fewer and the mathematics less extended. Concerning the quality of instruction and the thoroughness of students' work, no conclusive evidence can be found. When both the higher level of entrance and the larger content of the curricula themselves are considered, it seems safe to conclude that the final level of attainment to which present-day programs are directed is certainly more than one year, and probably nearly two, in advance of the standards of 1870.

## PART III. OUTLINE OF THE EVOLUTIONARY PROCESS

**Early Developments.**—The year 1870 was chosen as a point of departure for these studies because it may be said to mark the transition from the pioneer era in American engineering education to an era of rapid growth and consistent development. It will be recalled that the Military Academy at West Point had served as the principal source of formal training for engineers prior to the founding of Rensselaer Polytechnic Institute in 1824. Rensselaer revised its curriculum and added a distinct civil engineering course in 1829; its first engineering degrees were conferred in 1835; and in 1849 it remodelled its program on the lines of the leading French technical schools, increasing the time requirements from one to three years. The Lawrence Scientific School was established at Harvard and the Sheffield Scientific School at Yale in 1847. The University of Michigan pioneered in engineering instruction in the West, offering its first courses in 1853 and awarding its first degrees in engineering in 1860. The Morrill Land Grant Act of 1862 was an event of far-

reaching influence. The founding of the School of Mines at Columbia in 1864, the opening of the Massachusetts Institute of Technology in 1865, the establishment of the Thayer School of Civil Engineering at Dartmouth and the founding of Cornell University in 1867, the beginnings of Worcester Polytechnic Institute with its distinctive scheme of shop training in 1868, and the opening of the first laboratory for class instruction in physics at Massachusetts Institute in 1869, were all notable milestones in the early progress of engineering education in America.

In 1866 there were but six engineering colleges of established reputation and but 300 men had been graduated in the previous thirty-one years. By 1870 the indications of growth were considerable; twelve states had accepted the provisions of the Morrill Act; the total number of engineering colleges had mounted to twenty-one and the number of engineers graduated to 866. From its founding in 1852 until 1871 the American Society of Civil Engineers was virtually the only national organization of engineers. The present profession of engineering was still a single stem in 1870, but with budding indications of a branching growth. The Northern and Western states were in the full swing of a vast process of industrial expansion, railroad building, city development and land settlement which marked the economic rebound from the Civil War and greatly stimulated the demand for engineering services. In the older states of the East the transition from an agricultural era to an industrial era gave a strong impetus to the subdivision and specialization of the engineering profession. A half century of delay in the economic recovery of the South made the progress of engineering education in that region slow and difficult until the last two decades.

In the period leading up to 1870 science was struggling its way with difficulty to a place of freedom and equality in the educational scheme. It lived by sufferance in Eastern institutions with deeply rooted traditions of classical culture, though the newer institutions founded by the vigorous states of the Middle West to serve as instruments of social change no less than as seats of learning granted to science a more generous

hospitality. It was fairly imperative in these early days that applied science should seek an adequate home in the Eastern states in independent institutions, which did much to invest engineering education with its distinctive qualities and its traditional rigor.

**Early Educational Processes.**—Fletcher has pictured the state of engineering education prior to 1870 as follows:[1]

> "The schools had very inadequate resources; engineering laboratories for general instruction were practically unknown, although here and there a professor was improvising experiments on a small scale; text-books were few and many derived from abroad; instruction was probably more largely by recitation from the book, with great emphasis on purely mathematical exposition; . . . the subjects taught were much the same by name as those taught today (*i.e.*, in civil engineering in 1896), but not so many, nor as practically developed, and without aids now deemed essential; they were, however, fundamental and the capable student got a firm grasp of principles."

In another address the same writer continued:[2]

> "The great masters of mathematical exposition set a fashion of teaching which was criticized as too severe and impractical. School facilities being inadequate, and class laboratories almost unknown, the results of experimental research were dressed in mathematics and taught largely through the 'weight of authority' from the book; and while the instructor performed elementary experiments on the other side of the table, the class simply 'observed' and perhaps tried to 'take notes.'"

In his presidential address before the Society for the Promotion of Engineering Education in 1896 Mansfield Merriman threw further light on the teaching of this period:[3]

> "Thirty years ago public opinion looked with distrust on technical education. Its scientific basis and utilitarian aims were regarded as on a far lower plane than classical education. . . . Engineering courses a quarter of a century ago were scientific rather than technical. It was recognized that the principles and facts of science were likely to be useful in the

[1] *Proceedings*, S. P. E. E., Vol. IV, 1896, p. 31 et seq.

[2] Trans. Int. Eng. Congress, included in *Trans. A. S. C. E.*, Vol. 54A, 1905, p. 455.

[3] *Proceedings*, S. P. E. E., Vol. IV, 1896, p. 16.

every-day work of life and particularly in the design and construction of machinery and structures. Hence mathematics was taught more thoroughly and with greater regard to practical applications, chemistry and physics were exemplified by laboratory work, drawing was introduced and surveying was taught by actual field practice. Although engineering practice was rarely discussed in those early schools, and although questions of economic construction were but seldom brought to the attention of students, yet the scientific spirit that prevailed was most praiseworthy and its influence has been far-reaching.

"This scientific education notably differed from the old classical education in two important respects: first, the principles of science were regarded as principles of truth whose study was ennobling because it attempted to solve the mystery of the universe; and second, the laws of the forces of nature were recognized as important to be understood in order to advance the prosperity and happiness of man. The former point of view led to the introduction of experimental work, it being recognized that the truth of nature's laws could be verified by experience alone; the latter point of view led to the application of these laws in industrial and technical experimentation. Gradually the latter tendency became far stronger than the former, and thus the scientific school developed into the engineering college."

**Contrasts in Evolution of Engineering and Other Professional Curricula.**—The engineering curricula of 1870 were obviously derived from collegiate models as variants to the then existing curricula in modern sciences and languages, with modifications as pointed out by Merriman in the passage quoted above. Their origins and evolution were in quite the reverse direction to the course taken in the development of legal, medical and dental education. Formal education for these professions grew directly out of apprenticeship; it was initiated and conducted by practitioners, almost wholly on a proprietary basis, and it began on a purely practical and technical plane with none of the general qualities of collegiate education. Engineering education in America, practically from its inception, was in all essential respects a form of collegiate education; it was instituted and directed by educators rather than practitioners; it did not evolve from apprenticeship and only slowly and partially replaced it; it was never

on a proprietary basis; and it gained the patronage and support of practitioners with considerable struggle.

The dominant place given to purely general subjects in these early curricula points strongly to extensive borrowing from the collegiate curricula in modern branches and to the paucity of specific materials for engineering instruction. The large time allotment to foreign languages was plainly caused by the scarcity of treatises and texts in the English language and to the dependence of the student on French and German publications. There is little to suggest that these languages were studied primarily for their humanistic and commercial values; they were necessary tools; as time brought an increased output of suitable publication in English the need for such tools decreased and they were given proportionately less emphasis. The time devoted to English and to social studies is probably the best index to the cultural qualities of the early curricula.

**Developments from 1870 to 1885.**—This was the great formative epoch in American engineering education. The collegiate type of curriculum, with its extended base of science, mathematics, languages and social studies, though modified by the pressure of expanding engineering knowledge and technique, proved its stability and became firmly established as the basic process in American engineering education. The Centennial Exposition of 1876 did much to popularize and stimulate technical education. The attention of leading educators, notably President Runkle of the Massachusetts Institute of Technology, was attracted by the exhibit of the methods and products of a system of manual training which had been developed in Russia. A strong impetus was given to the introduction of similar methods of training, both in engineering colleges and in secondary schools. By 1885 shop work had attained its maximum position in engineering curricula, as measured by time allotment, and considerably overshadowed the emphasis on laboratory instruction in the engineering branches. Laboratory teaching of the physical sciences, however, was greatly extended in this period and

substantial progress made in developing laboratories of engineering.

The period between 1870 and 1885 was marked by the expansion and diversification of the engineering profession, as indicated by the founding of the American Institute of Mining and Metallurgical Engineers in 1871, the American Society of Mechanical Engineers in 1880, and the American Institute of Electrical Engineers in 1884. Similar influences were at work in the colleges and it was in this period that the basic scheme of differentiated curricula in the major technical branches of engineering became firmly established. The expansion of mechanical engineering education in this period was especially notable. Toward the end of the period the foundations of distinct curricula in electrical engineering were laid at Massachusetts Institute and at Cornell. In both instances the new curriculum developed under the fostering of the department of physics, a further striking indication that engineering curricula evolved from the scientific toward the technical, rather than in the reverse direction as in other branches of professional education. Fifteen years later these evolutionary steps were repeated in the growth of distinct curricula in chemical engineering.

The provisions of the Land Grant Act of 1862 were widely adopted by the states during this period, resulting in a rapid growth in the number of engineering colleges. The conspicuous models set by Rensselaer, Michigan, Massachusetts Institute and Cornell were widely copied in these newer institutions. The early results, to be sure, were often but remote approximations to the models chosen, but the effect in the long run has been sound. Standardization by imitation has manifest limitations, but it has probably saved engineering education from any considerable admixture of shoddy.

Of all the elements of progress in this period, possibly first rank should be given to the beginnings of an epoch of notable teaching and authorship by Merriman, Fuertes, DeVolson Wood, Thurston, Johnson, and others. American engineering education turned definitely from European models and

sources to seek its leadership and materials on its own fertile ground.

**Developments from 1885 to 1900.**—It is in this period that engineering education in America may be said to have come into its own. Great industrial expansion and notable progress in invention caught the popular imagination. Education in applied science grew in popularity to a point where it seemed to threaten not merely the preeminence but even the actual existence of classical culture for young men. The number of engineering colleges grew with great rapidity, both through the operations of the Land Grant Act and through private benefactions. By 1896 the number of such institutions had risen to 110.

Much of this expansion took place on a fairly low academic level. A classification of engineering colleges with reference to their entrance requirements, made in 1896, showed the following grouping:[1]

Class A, 31 colleges; requiring for entrance at least algebra through quadratics, plane geometry, solid geometry or plane trigonometry, one year of foreign language, and moderately high requirements in English.

Class B, 33 colleges; requiring algebra through quadratics and plane geometry.

Class C, 25 colleges; requiring less than algebra through quadratics and plane trigonometry.

Class D, 18 colleges; not offering complete courses in engineering, but giving analagous work, generally under the head of mechanic arts; many in process of developing into true engineering colleges.

Class E, 3 colleges; having no entrance requirements as such, but doing engineering work of good grade.

The lax requirements of many engineering colleges at this period (1896) as compared with the old-line classical colleges were regarded by the better grade of preparatory schools as a demoralizing influence and led to many complaints.

One of the most significant events in the period under con-

[1] *Proceedings*, S. P. E. E., Vol. III, 1895, p. 25 et seq., and Vol. IV, 1896, p. 101 et seq.

sideration was the formation of the Society for the Promotion of Engineering Education in 1893. It promptly drew to itself the leading spirits in engineering education. Its early rosters of officers and members give evidence of the dominant influence of a small group of notable institutions with sound standards and progressive policies. Beyond question the moral influence of this organization was a primary force in preserving the norm of high scholastic standards and the ideal of a relatively liberal, collegiate type of curriculum.

It was in this period, more than any other, that the laboratory method of instruction in engineering branches grew to its dominating position. This change was due in part to the rise in importance of mechanical and electrical engineering. Early curricula had been dominated largely by the model of civil engineering, with its emphasis on design and field work. The early civil engineering curricula in their turn had been largely influenced, directly and indirectly, by French models characterized by an emphasis on didactic methods of instruction and on mathematical and analytical, rather than experimental methods of attack. By 1900 it was generally recognized that American laboratory installations and methods for the teaching of engineering were not surpassed and not often equalled in any other part of the world. As much could not rightfully be claimed, however, for much of the theoretical instruction and especially for instruction in design.

Among the specific changes in curricula between 1885 and 1900 may be noted the distinct recovery of ground by the physical sciences, the progressive transfer of elementary mathematics from college curricula to entrance requirements, the reduction of time given to drawing and shop work as distinct subjects in favor of the engineering subjects as such, the diminished emphasis on foreign languages in consequence of the rapid growth of an indigenous engineering literature and the pressure of increasing technical specialization, the recovery of ground by English and the emergence of economics to a place of prominence among the group of social sciences. The beginnings of chemical engineering as a distinct curriculum marked the end of the period.

**Developments since 1900.**—The turn of the century saw engineering education in America near the climax of its popularity relative to other major divisions of higher education. As the second decade developed agricultural education sprang into prominence and as it closed collegiate education for business was in a rapid upswing. These developments somewhat checked the expansion of engineering education and probably for its good. The events of the World War, however, served to direct attention to engineering education anew. The prominent place gained by engineers in the direction of industry, the notable contributions of engineering to the technique of production, and the conspicuous place taken by engineers in war activities, led to a marked increase of emphasis on the administrative and economic side of engineering.

The influence of this march of events on engineering curricula is apparent. Distinct curricula to emphasize the administrative rather than the technical aspects of engineering were introduced rather widely. The place given to economics in all curricula was augmented, often at the expense of time previously given to other social subjects. Business electives in engineering curricula were more widely provided. Since the war there has been a discernible trend away from specialization for undergraduates. The effort to stretch a four-year college program into an all-round or a specialized training is being frankly abandoned, with a reaction toward simplification of programs and a greater emphasis on general training.

**Cooperative Plan.**—The development of the cooperative method of engineering education, based on alternate periods of instruction in college and of experience in engineering works and industries has been a prominent feature of this period.

Part-time education, combined with productive employment, had been in operation in both Europe and America for well over one hundred years but the plan instituted at the University of Cincinnati in 1906 was new in so far as it involved the pairing of students, and their wide distribution in industry under the alternating plan. Similar plans have since been

adopted in greater or less degree in nearly one-eighth of the engineering colleges of the United States, and have attained a secure and stable position. There are now seven institutions which use this method exclusively, throughout all stages of their curricula, and six others require it in certain years of all their programs. In five other cases the method is employed as an alternative to the usual all-resident plan. When given the benefit of equally strong personnel and ample facilities, the cooperative plan is quite generally accepted as a worthy alternative to the all-resident plan in combination with part of the usual industrial or professional apprenticeship. It has certain economic advantages and leads to certain administrative complications. What unique merits it may claim, judged purely as an educational process, and what distinctive type of product it leads to, are not yet adequately determined.

**Characteristics of Present Curricula.**—Engineering curricula, in their more essential qualities, are to-day what they were fifty years ago—a distinctive type of college program based primarily on the principles and applications of physical sciences and mathematics, with associated studies in languages and social sciences, and intended to precede and supplement, but not supplant, an extended professional apprenticeship. College training is assumed to provide the more general, and apprenticeship the more specific, preparation for an engineering career. The numerous changes of detail in the course of fifty years do not invalidate this characterization.

A high degree of structural unity has always been a striking characteristic of engineering curricula. There are close-knit, logical sequences of subject matter running from beginning to end with a fairly intimate coordination of detail between the separate subjects. Few subjects in the curriculum are treated in an wholly discrete manner. The tendency is to plan the curriculum with a view to the whole which is something more than the mere aggregate of its parts. While it is impossible to speak with finality, there are indications that present curricula are closer knit, in a formal sense, than those of earlier years; on the other hand, loss of intimacy be-

tween individual teachers and departments, due to expansion and subdivision of organization, has worked against the desired coordination.

The striking stability of the broader features of these curricula throughout a half century of revolutionary changes in other realms of higher education may be ascribed either to stubborn conservatism or to the fundamental soundness of engineering programs, according to the view-point of the individual. The latter seems to be much the more reasonable alternative. There are few if any branches of higher education which are more severely tested by objective realities, nor are there any in which the content of curricula is more constantly and critically scrutinized for its relevancy, in consequence of the rapid advance of knowledge and technical practice and the enforced limitations of time. The testimony of graduates, practitioners and employers gives ample support to the fundamental soundness of engineering education in its general plan, while indicating the need of many betterments of detail.

**Are Present Curricula Illiberal?**—There is a tendency among some educationists to characterize engineering education as narrow, specialized and illiberal. It is impossible to say how largely these assertions are based on informed judgment and how largely on vague impressions arising from the contrast between an integral curriculum combining general and technical training and the tandem plan of distinct preprofessional and technical stages which has been developed in legal, medical and dental education. Excluding physical and military training, engineering curricula may be subdivided into five principal divisions, as in the following table:

PRINCIPAL GROUP REQUIREMENTS IN ENGINEERING CURRICULA, EXPRESSED IN ACADEMIC YEARS

| | 1870 | 1885 | 1900 | 1915 | 1923 |
|---|---|---|---|---|---|
| Humanistic | 1.137 | .706 | .653 | .560 | .516 |
| Scientific | 1.385 | 1.091 | 1.094 | 1.065 | 1.127 |
| Free electives | .026 | .059 | .048 | .084 | .151 |
| General technology | .939 | 1.143 | 1.173 | 1.136 | 1.068 |
| Special technology | .509 | .882 | .965 | 1.122 | 1.095 |

In the face of the above facts it can not be asserted that engineering curricula have become more liberal as a result of evolution. The peak of specialization has been passed, free electives have increased, there has been a gain of scientific content and emphasis, but humanistic content has decreased. Since 1885 this loss has been entirely due to the declining status of foreign languages, and the low valuation placed by graduates on their training in this field suggests that the loss of humanistic emphasis in that period has been more apparent and real. It would seem, however, that some more adequate compensation in English studies and the social sciences might have been expected.

The increase of technical specialization has also probably been more apparent than real, when it is considered that time transferred from physical sciences to engineering subjects is by no means lost to scientific culture, that the reduced time devoted to mathematics has been fully offset by gains in average entrance requirements, that the growth of time given to technical engineering subjects has been primarily at the expense of graphics and shop work, and secondarily at the expense of foreign languages formerly studied as necessary keys to foreign technical literature, and that the reduced requirement in the social studies has been largely offset by the provision for a wider range of such studies on an elective basis.

When all reasonable allowances have been made for compensating elements not appearing on the face of the data, it still remains true that the trend of evolution up to 1915 was away from a broad educational emphasis and toward a specialized training. Since that date there has been a perceptible trend toward broader educational ideals and programs.

**Comparison of General Content with Pre-professional Curricula.**—The generalized picture of engineering curricula given in Fig. 11 makes it apparent that practically 1.8 academic years of general training which would be entirely acceptable toward a degree in arts are included. It should be recalled that the unit academic year refers strictly to prevailing requirements in engineering colleges, which are from

twenty to twenty-five per cent greater in volume than those of a typical arts college for an equal period. It is therefore entirely conservative to state that the average engineering curriculum includes the equivalent of more than two years

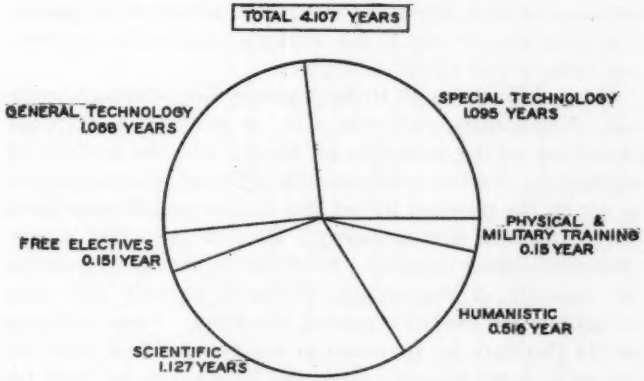


FIG. 11. Major divisions of the composite engineering curriculum of 1923–24.

formal training in a college of liberal arts.[1] The collegiate work prescribed for admission to Class A schools of law and medicine is two years, and a like requirement is being put into effect in dentistry. There is a significant difference behind the apparent equality of these pre-technical educational requirements, namely, that a much higher proportion of such work prescribed for engineers bears an organic relation to the technical studies which follow.

Considering both phases of training, the general and the technical, the engineering student gets as much general training as is required of the student of law or medicine, but is confined within a narrower range of choice and permits less emphasis on distinctly humanistic subjects; he gets less technical training in college and has greater occasion to extend his training through apprenticeship and post-scholastic study.

[1] For confirmation see *Jour. Eng. Edu.*, Jan., 1927, p. 468.

It should be noted, however, that two-thirds of the students entering the technical study of medicine hold college degrees or are to receive them in an additional year of a combined program, and that a considerable number of the stronger medical schools admit only such students. There is a similar tendency in legal education, though less advanced at present. Less than ten per cent of the students admitted to engineering colleges hold collegiate degrees.

**General Qualities of Undergraduate Engineering Curricula.**—Engineering curricula aim to provide a thorough grounding in the principles of science and the methods of engineering, together with elements of liberal culture intended to enrich the personal life of the student and fit him for a worthy place in human society. They do not afford a complete professional training. Whatever their original purpose, the majority of engineering graduates actually put their training to the uses of a general education. These curricula should therefore be appraised as a type of college training, aiming at large general values and intended to lay only the broader rather than the specialized foundations for a professional career. They draw on many fields of knowledge, but not at random. They bring the selected elements to a common focus in a distinctive field of technical activity. What they lack in freedom for a wide ranging over the whole area of human thought must be weighed against the values inherent in organized and directed effort under circumstances favorable to strong motivation. The present trend of evolution is toward a greater emphasis on general, rather than technical, educational values in undergraduate college work, and toward the more extended development of supplementary stages of specialized training for subsequent years.

## PART IV. TABLES OF DATA

1. CASES INCLUDED IN THE ANALYSES OF ENGINEERING CURRICULA

| | Alabama Polytechnic | Case | Cornell | Illinois | Iowa State College | Lehigh | Mass. Inst. Tech. | Michigan | Purdue | Wisconsin |
|---|---|---|---|---|---|---|---|---|---|---|
| **Civil Engineering:** | | | | | | | | | | |
| 1870 | | | | | × | × | × | × | × | × |
| 1885 | | | × | | × | × | × | × | × | × |
| 1900 | | × | × | × | × | × | × | × | × | × |
| 1915 | × | × | × | × | × | × | × | × | × | × |
| 1923 | × | × | × | × | × | × | × | × | × | × |
| **Mining Engineering:** | | | | | | | | | | |
| 1870 | | | | | × | × | × | | | × |
| 1885 | | | | | | × | × | | | × |
| 1900 | | × | | | × | × | × | | | |
| 1915 | | × | | × | × | × | × | | | × |
| 1923 | | × | | × | × | × | × | | | × |
| **Mechanical Engineering:** | | | | | | | | | | |
| 1870 | | | | | × | × | × | × | × | |
| 1885 | × | | × | | × | × | × | × | × | × |
| 1900 | × | × | × | × | × | × | × | × | × | × |
| 1915 | × | × | × | × | × | × | × | × | × | × |
| 1923 | × | × | × | × | × | × | × | × | × | × |
| **Electrical Engineering:** | | | | | | | | | | |
| 1885 | | | × | | | | × | | | |
| 1900 | × | × | × | × | × | × | × | × | × | × |
| 1915 | × | × | × | × | × | × | × | × | × | × |
| 1923 | × | × | × | × | × | × | × | × | × | × |
| **Chemical Engineering:** | | | | | | | | | | |
| 1900 | | | | × | | | × | × | | |
| 1915 | × | × | | × | × | × | × | × | × | × |
| 1923 | × | × | | × | × | × | × | × | × | × |

2. COMPOSITE RESULTS OF ANALYSES OF ENGINEERING CURRICULA

| Curriculum | Year | Number of Cases | Engineering—Major Branch | Engineering—Other Branches | Mechanics and Hydraulics | Graphics | Shop Work | Free Electives | Physical Sciences | Mathematics | Economics | Other Social Sciences | English | Foreign Languages | Physical and Military Training |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Civil Eng. | 1870 | 6 | .576 | .124 | .240 | .437 | .000 | .066 | .739 | .636 | .042 | .182 | .302 | .621 | .043 |
| | 1885 | 7 | 1.145 | .059 | .393 | .338 | .016 | .110 | .566 | .567 | .041 | .136 | .159 | .356 | .125 |
| | 1900 | 9 | 1.248 | .134 | .398 | .273 | .060 | .054 | .640 | .540 | .076 | .053 | .194 | .295 | .084 |
| | 1915 | 10 | 1.465 | .231 | .441 | .242 | .074 | .082 | .548 | .477 | .062 | .064 | .235 | .172 | .147 |
| | 1923 | 10 | 1.300 | .226 | .426 | .252 | .032 | .187 | .613 | .453 | .123 | .066 | .234 | .122 | .148 |
| Mining Eng. | 1870 | 4 | .596 | .441 | .230 | .397 | .000 | .000 | .809 | .627 | .062 | .116 | .309 | .476 | .064 |
| | 1885 | 3 | .884 | .572 | .169 | .512 | .000 | .000 | .582 | .565 | .024 | .100 | .099 | .473 | .172 |
| | 1900 | 4 | .781 | .630 | .298 | .188 | .025 | .000 | .912 | .428 | .049 | .035 | .203 | .388 | .052 |
| | 1915 | 6 | 1.059 | .525 | .340 | .195 | .051 | .071 | .858 | .435 | .062 | .027 | .227 | .182 | .177 |
| | 1923 | 6 | .990 | .400 | .316 | .168 | .032 | .040 | 1.020 | .454 | .151 | .027 | .208 | .120 | .155 |
| Mech. Eng. | 1870 | 5 | .360 | .279 | .239 | .471 | .061 | .000 | .731 | .624 | .049 | .305 | .289 | .623 | .034 |
| | 1885 | 8 | .712 | .149 | .279 | .424 | .447 | .050 | .377 | .662 | .023 | .176 | .243 | .330 | .104 |
| | 1900 | 10 | .925 | .274 | .379 | .288 | .369 | .048 | .464 | .538 | .059 | .052 | .236 | .317 | .095 |
| | 1915 | 10 | .997 | .347 | .416 | .257 | .271 | .100 | .449 | .493 | .099 | .041 | .235 | .204 | .154 |
| | 1923 | 10 | 1.065 | .355 | .407 | .239 | .273 | .139 | .444 | .449 | .104 | .056 | .223 | .132 | .147 |
| Elec. Eng. | 1885 | 2 | .634 | .527 | .356 | .494 | .275 | .000 | .409 | .662 | .021 | .082 | .087 | .328 | .125 |
| | 1900 | 10 | .856 | .486 | .325 | .262 | .265 | .044 | .427 | .570 | .066 | .051 | .235 | .305 | .104 |
| | 1915 | 10 | 1.067 | .491 | .343 | .246 | .205 | .053 | .453 | .499 | .083 | .043 | .233 | .193 | .154 |
| | 1923 | 10 | 1.100 | .417 | .341 | .215 | .159 | .199 | .487 | .481 | .100 | .040 | .245 | .121 | .146 |
| Chem. Eng. | 1900 | 3 | .858 | .466 | .163 | .300 | .198 | .107 | .738 | .405 | .042 | .026 | .121 | .494 | .075 |
| | 1915 | 9 | 1.014 | .514 | .216 | .167 | .084 | .111 | .732 | .488 | .061 | .053 | .221 | .281 | .161 |
| | 1923 | 9 | .967 | .488 | .210 | .146 | .078 | .144 | .959 | .441 | .060 | .040 | .202 | .197 | .154 |

3. General Composite Analyses of Combined Curricula

| Curriculum | Year | Number of Cases | Engineering—Major Branch | Engineering—Other Branches | Mechanics and Hydraulics | Graphics | Shop Work | Free Electives | Physical Sciences | Mathematics | Economics | Other Social Sciences | English | Foreign Languages | Physical and Military Training |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Composite of all curricula | 1870 | 15 | .509 | .260 | .237 | .438 | .020 | .026 | .755 | .630 | .050 | .205 | .299 | .583 | .046 |
| | 1885 | 20 | .882 | .219 | .310 | .414 | .212 | .059 | .477 | .614 | .029 | .141 | .176 | .360 | .124 |
| | 1900 | 36 | .965 | .353 | .342 | .267 | .211 | .048 | .570 | .524 | .063 | .047 | .212 | .331 | .088 |
| | 1915 | 45 | 1.122 | .410 | .355 | .225 | .146 | .084 | .583 | .482 | .075 | .047 | .231 | .207 | .157 |
| | 1923 | 45 | 1.095 | .373 | .362 | .208 | .123 | .151 | .671 | .456 | .105 | .048 | .224 | .139 | .150 |

4. Amounts and Percentages of Principal Group Totals in the General Composite Results

| Year | Number of Cases | Total Academic Years | Total Specific Engineering Subjects | | Total—Prescribed Technical Subjects | | Total—Preser. Tech. Subjects & Free Electives | | Total—Mathematics and Physical Science | | Total—Language and Social Sciences | | Total—Non-technical Subjects | | Total—Non-tech. Subjects and Free Electives | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Amt. | % | Amt. | % | Amt. | % | Amt. | % | Amt. | % | Amt. | % | Amt. | % |
| 1870 | 15 | 4.042 | .769 | 19.0 | 1.448 | 35.8 | 1.474 | 36.5 | 1.385 | 34.3 | 1.137 | 28.1 | 2.568 | 63.5 | 2.594 | 64.1 |
| 1885 | 20 | 4.017 | 1.101 | 27.4 | 2.037 | 50.8 | 2.096 | 52.3 | 1.091 | 27.2 | .706 | 17.6 | 1.921 | 47.9 | 1.980 | 49.3 |
| 1900 | 36 | 4.021 | 1.318 | 32.8 | 2.138 | 53.1 | 2.186 | 54.4 | 1.094 | 27.2 | .653 | 16.2 | 1.835 | 45.6 | 1.883 | 46.8 |
| 1915 | 45 | 4.124 | 1.532 | 37.1 | 2.258 | 54.7 | 2.342 | 56.8 | 1.065 | 25.8 | .560 | 13.6 | 1.782 | 43.2 | 1.866 | 45.2 |
| 1923 | 45 | 4.105 | 1.468 | 36.6 | 2.161 | 53.9 | 2.312 | 57.6 | 1.127 | 28.1 | .516 | 12.8 | 1.793 | 44.7 | 1.944 | 48.4 |

# THE PROBLEM OF ENGINEERING EDUCATION FROM THE STANDPOINT OF AMERICAN INDUSTRY.*

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It may perhaps be superfluous, after all that the National Industrial Conference Board and the Society for the Promotion of Engineering Education have been trying to do together, to reiterate and reëmphasize the fundamental sources of the interest of industry in the problem of engineering education. But since the teaching profession, necessarily occupying itself with the purely educational aspects of the problem, may frequently lose sight of the distant and intangible goal toward which we all are working, it may not be amiss on this occasion to point out, in the light of the present situation, the importance of the educational problem for industry.

The amazing economic development of the United States during the past half century has become a byword among all the nations of the world. The growth of our productive power, the diffusion of material prosperity and the progressive raising of the standard of living of our people have caused the nations of Europe, impoverished by war and disorganization, to look increasingly to the United States as a guide and example by which they may hope to find their way out of the slough of despond. Judging by the way in which scores of European industrialists, business men, labor leaders, economists, and technicians have lately been visiting the United States—and most of them eventually find their way to the offices of the Conference Board—Europe appears to feel that we Americans have discovered some esoteric secret of easy prosperity or dug up some Aladdin's lamp of effortless wealth.

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Nor can we blame them for this attitude, for to a great extent it is true. As if by magic, the tangible wealth of the United States per capita, measured in dollars of constant value, has increased nearly fourfold since 1870. The national income, that is the wealth produced annually by the American people, has multiplied in terms of the same dollar nearly eight times since 1870. The volume of the products of our industries has increased even more rapidly while wages have risen to an heretofore unknown extent. To-day, if we take the real wage of industrial workers in our country, that is, the volume of goods and services which the money wage will buy here, as the basis of 100, we find that the real wage of workers in Canada in reference to the price of goods and services in that country is by comparison only 89 and, similarly, that in Australia is 78, in Denmark 67, in England 60, in Sweden 52, and so on through all of the European countries down to Belgium in which the real wage of workers, which is the material satisfactions they get in their own country for their labor, is 26 or only about one quarter that of the workers in the United States.

And what is this secret or magic formula which puts the prosperity of the American worker on so much higher a level than the rest of the world? It is assuredly not merely the vast natural resources of our country in materials and power that of itself has made this vast development, for these have been available for untold ages but have been brought into the service of man only during the past hundred years. Europe, too, has at this day vast unexploited resources and possibilities of which she has not as yet made full use because for centuries her interest has been directed largely outward toward the exploitation of the resources of other countries. Nor can it be said that Europe has in any way fallen behind the United States in the development of scientific and technological knowledge, for Europe in many respects has been the birthplace of science and its growth and diffusion have been carefully fostered.

The marvelous economic development of the United States

has rather been due to the characteristics of her people and especially to her industrial leaders. It is this quality of leadership that has been the Aladdin's lamp which has summoned science, natural forces and natural wealth to the service of man. This quality of leadership has involved not only accumulation of scientific and technological knowledge and their application to industry and trade, but exercise of initiative, persistence, courage, vision and broad human wisdom in the organization of men, money, materials and machines so as to create this vast structure of industry and commerce which alone has made knowledge fruitful.

The emergence of industrial leadership and the importance of industrial management in our economic development is discernible most clearly during the past decade. During this period, the production of American industry has increased in comparison not only with the amount of human labor involved but also in comparison with the amount of power used. If we compare the year 1914 with the year 1923 we find that for each unit of production of our manufacturing industries there were required in 1923 13 per cent less installed power, 25 per cent fewer wage earners, 17 per cent less management personnel than in 1914. This more efficient utilization of both power and labor has made possible in that period a decrease of 7 per cent in the average hours of work per wage earner and a 36 per cent increase in the wages paid to the average worker in industry, while the average production per wage earner rose fully 3 per cent.

It is obvious that continuance of this development in the future depends not only upon the same factors which have given rise to it in the past, but upon their constantly more intensive application. The increase of our population and the habit of expanding standards of living to which we have been accustomed, as well as the rapid exhaustion of some of our natural resources have brought new problems in their wake, but have also created a constantly increasing demand for a still higher quality of industrial leadership. We require of this leadership not only ability to apply scientific

knowledge, but also a clear understanding of fundamental economic, social and political factors which constitute the environment of industry and will so greatly affect its growth in the future. The industrial leader of the future must be not only an efficient producer but he must carry his leadership, initiative and vision further into the fields of problems of industrial and human, social and political relationships, of distribution, trade and international affairs, than has been necessary for him in the past.

The National Industrial Conference Board's current survey of the qualities and training of the men in various ranks of the managerial group in industry shows clearly that the college educated and technically trained men play an important rôle in our industrial life. It also indicates that industry will look increasingly to our colleges and engineering schools for men adapted and qualified by reason of knowledge and qualities of character to assume both major and subordinate rôles in the ranks of industrial leadership in the future. If, as the Conference Board's study shows, only a little more than one quarter of the men in important positions in industry today have been the product of a general or engineering college training, we must remember that the period of our industrial development, which is behind us, was one in which the rôle and opportunity of the self-educated man, the product of the school of life, were much larger than may be true in the future. With the increasing complexity of industry, its constantly growing dependence upon technological improvement, as well as its interdependence with trade and commercial, financial and political factors, there will be required a type of industrial manager and a type of training for such leadership quite different from that which characterized the quarter-century that has passed.

It is clear, therefore, that industry is bound to have an increasingly close and direct interest in the quality and training of the men who come to it from our colleges and universities; and it is in recognition of this fact and of the social responsibility which thereby attaches to industry, that the

Conference Board has sought to indicate the lines along which both industry and the schools may better coöperate in order better to achieve the purposes of both. As a basis for this, the Conference Board has surveyed, from the point of view of industrial experience, the situation in regard to the position of the college trained man in the industries in order to indicate the qualities and training most desired for its recruits from colleges, the deficiencies found to be most common in the graduates of our engineering schools, the respects in which the objectives, methods, curricula and teaching staff of the colleges seem to fall short of supplying the type of training needed, and the ways in which the industries and the colleges may better coöperate to secure a greater degree of coördination between engineering education and industrial requirements.

To make this study concrete, six basic industries were selected for specific investigation, namely: the chemical, paper and pulp, rubber, textile, metal trades and electrical manufacturing industries. In each case it was sought to determine whether men in leading positions have had a college, and specifically an engineering college, education, what men having had an engineering education are now engaged in these industries, and what positions they occupy. It was sought also to determine from the management, from engineers and technically trained men in each industry, what further opportunities the industry offers for the employment of additional men with engineering training, and in what respect those industrialists believed the engineering schools might make their graduates more responsive to the practical needs of industry. Since many of the industrialists who replied to the question regarding engineering school programs had themselves had an engineering training, their judgment may be considered especially noteworthy; they have had opportunity to test the value of their own engineering training in fitting them for their positions and could judge also the reasons for failures and successes of similarly trained men as well as of non-college and non-technically educated co-employees.

To gather the evidence for this study, three questionnaires were issued. One was addressed to the managers of industry to secure numerical data on the number, education and position of college men in industry and of non-college men in leading positions; a second was addressed also to the managers to obtain from those responsible for the success of the industries information regarding methods of effective coöperation with the schools and opinions on the type of engineering college training that would be most beneficial; and a third was addressed to college men in industry to secure data on their past education, their views as to its shortcomings in relation to their practical life, information on the present positions held by them, on their educational activity during work or leisure time, and on other details of their immediate industrial environment.

All college men were included in the study, whether engineering or other college training, provided they occupied any one of a list of selected positions in the technical and administrative fields in which engineering training would seem to be warranted as a special aid toward achievement. College trained men occupying minor positions, either for the purpose of gaining initial experience or for any other reason, such as inability to locate a position where a college education is of value, were not included.

These questionnaires were prepared on the basis of the experience with those of the earlier study of the Conference Board, as summarized in its report issued in August, 1923. The concluding paragraph of that report said, "It is rapidly being recognized that during the last period of engineering education and the first period of engineering practice, the engineering school and industry have a common problem; and the closer the coöperation during this period of transition, the more beneficial will be its result for the young man, the school from which he graduates, and the industry which he is planning to serve as his life work." Therefore, some of the questions on the questionnaire addressed to industrial management were planned to discover the present extent to which industry coöperates with the engineering schools.

The coöperation of national engineering and industrial associations was obtained to assist in enlisting the active interest of industrial establishments in the Board's study. A large number of establishments, and of college men, were canvassed and contributed relevant data.

It would have been a difficult and a much prolonged task to obtain data from every establishment in the industries considered but the extent of this investigation was such as to represent a large percentage of these industries. The number of companies to which questionnaires were sent, 3,631, was more than 10 per cent of the total in these industries as reported by the Census of Manufactures for 1921.

The data used in this study came from 722 of these companies, which operate 1,081 separate establishments. These establishments employed about 20 per cent of all the persons engaged in the selected positions. The detailed analysis of their personnel, as made by the managements of these companies, revealed that over 12½ per cent of the total employees occupied positions which had been listed and been considered of such a technical and supervisory character as to warrant the use of men with collegiate education.

These analyses of the various managements also showed that 15,254 of the men in these selected positions were college trained; that is 28 per cent of all those in the technical and supervisory group. A large proportion of these was canvassed to obtain further information on this subject, with the result that 2,433 college men responded to the inquiry. It is thus evident that a sufficient percentage of the employees of the six industries is covered in the data obtained to provide a very fair sampling.

A careful inspection of the replies to questionnaires with respect to the size of establishment, type, geographical location and other factors confirms the opinion that the groups of men and of establishments who contributed data are fairly typical of the industries as a whole. The age distribution of the men who returned questionnaires was such as to insure a fair consensus of opinion from men of all degrees of maturity and

experience. The replies were from men as young as twenty to those of ripe age, reaching to ninety-four years, the average age being 36 years. Moreover, the data secured come from both college men as employees of industry and from industrial executives representing the management of industry, whether they were college men or not. Obviously, most of the men in charge of, and speaking for, the industrial establishments were college trained men, yet the general character of replies from the many non-college trained executives was in no way noticably different from that made by college trained men in industry. Men were included in the study as college trained if they had attended college two years or more, whether or not they received a degree. Of the 2,433 college men thus included, 81 per cent had received a regular college degree and 11 per cent had received two or more college degrees. In general, even allowing for all the usual shortcomings of such questionnaire inquiries, it may fairly be claimed that, on the whole, the data assembled are substantially representative for the purposes of this study. Qualitative rather than precise quantitative results are significant in matters of this kind.

The type of education with which that report is concerned is that usually given in the engineering courses of institutions of recognized college grade. It was not intended to include education of the trade school or specialized technical school of non-collegiate character. The college men studied are those who have had technical training of college grade in civil, mining, mechanical, electrical, chemical and industrial engineering, in engineering administration and in the technical aspects of the natural sciences generally.

The Conference Board's report on this survey, which will be published shortly, is offered as industry's contribution to the discussion of the problem of the relationship between Engineering Education and American Industry, in the hope that the industries and their leaders approaching the question from the one side, and the engineering colleges and their teachers approaching it from the other, may meet upon a more or less common ground upon which to build a con-

structive program for the future. I trust that it will have your earnest and sympathetic consideration from this point of view.

At this time, I am not going to attempt to summarize the results of the Conference Board's study, but rather to lay emphasis upon several points which are suggested by the Board's survey as well as by my own extensive industrial experience which has brought me into close contact with thousands of graduates of the engineering departments of our colleges and universities.

There are, it seems to me, four fundamental considerations which form the basis for any program of better adjustment between the engineering schools and the industries.

The first is the *quality of the student material* upon which the engineering college is to work. If bricks cannot be made without straw, or if a silken purse cannot be made of a sow's ear, then it is even more true that industrial leaders or good engineers cannot be made out of men who by character, temperament or mentality are not suited or intended to be such. In our all too blind faith in the universal efficacy of education and in the principles of literal equality as applied to education, we have been too ready in all branches of our school system to ignore the inherent differences between men, be they the result of heredity or environment. These differences tell even more in specialized education. Thus, effective industrial leadership and distinctive service in the engineering profession requires men of certain qualities of character, mental outlook and ability, and if these are lacking it is hardly possible to remedy the deficiency by the mere application or administration of technical knowledge. In order for the work of the engineering colleges in training men to be more effective in relation to industrial needs, it is therefore necessary that there be a more pertinent and intelligent selection of the material for engineering training by means which test inherent interests, capacities and qualities of character rather than information alone. This selection must be applied to candidates for entrance into the colleges but also to the elimination

of the unfit throughout the college work. The problem of selection, and that of vocational guidance which is closely connected with it, naturally reaches back of the colleges into the secondary and even the primary schools, as well as beyond the colleges into industry which itself must be prepared to exercise greater discrimination in selecting its recruits from the colleges. But the bulk of the responsibility inevitably rests upon the engineering college both in the admission of the student material and its handling through the educative process.

In the second place, the problem of *selection and vocational guidance* is inevitably closely connected with that of the educational objectives in the engineering schools. It is hardly possible intelligently and effectively to select and guide the engineering student in relation to the needs of industry unless the schools have a clear conception of the relative importance of various types of men for the industrial organization. The number of positions of executive or managerial responsibility in industry is naturally relatively small as compared with the large number of positions requiring special training or technical knowledge sufficient for the careful and accurate carrying out of plans and projects originating with the higher executives. The latter need to be men of broad knowledge and cultural background, with a thorough grounding in the fundamentals of science and scientific method, as well as outstanding qualities of character required for the organization of men. The great bulk of such men as draftsmen and designers, construction engineers and test experts, and minor technical assistants, all of whom play their important and necessary rôle in industry, require rather a specialized type of technological knowledge and technical training that is suited to the needs of their particular functions in the industrial organization.

For either of these two groups it would appear that the prevalent content and method of engineering college education, which aims to provide a complete technical equipment, goes rather wide of the mark. To prepare men for the first

type of work in industry, it would appear that the engineering education should be of a broader and more simplified kind, aiming to give a thorough grounding in the fundamentals of science and scientific method, a good understanding of the economic, financial and business aspects of the industrial problem, a broad background of cultural and historical studies and a fair grasp of problems of human and labor relations. At the same time, there should be appropriate efforts to bring out apparent qualities of character and general abilities that are essential parts of the equipment of leadership. For the second group, it is questionable whether a collegiate engineering education is necessary or desirable at all, and whether the special knowledge or skill required for effective work in these positions cannot as well and more economically in time and money be acquired in trade or non-collegiate technical schools. Between these two groups there lies a large group of technical men in industry upon whom rests the responsibility for originative work in the scientific field and for these, of course, the thorough engineering training along established lines is desirable, although there is need for a close correlation of such specialized technical work in relation to the changing technical problems with which industry has to deal. It seems clear, however, that to provide all these three groups with the same type of engineering education is to fail to fill the needs of industry as they now present themselves and to fit also to men in each group for the service that they would best be suited to render to society and themselves. Such a training inevitably tends to be too narrow for the requirements of the group of industrial leaders and to be excessive and wasteful in respect to the requirements of the great majority of technical positions in industry.

In the third place, no matter how carefully the student material be selected or the objectives of the engineering school be proportioned in relation to the requirements of industry, it remains true that the production of good men depends ultimately upon the *quality and influence of the teaching staff*. Upon the teacher rests more than the responsibility of ef-

fectively administering knowledge. What ultimately determines the effectiveness of transmission of knowledge, however extensive it may be on the part of the teacher, are two closely related factors: the profundity of his knowledge, that is, the security and firmness of his grasp upon the fundamentals, and the strength and contagion of his personal force. The teacher is more than a siphon of information; he is rather an electrical conduit of inspiration and example. His personal influence for better or for worse is inevitably a dominant factor in the educational process. If the teaching staff of our schools and colleges are mediocre personalities, if they are mere pedants, if they are failures as men, if they are crabbed with disappointment at their fancied or real lack of opportunity to function actively and distinctively in life's affairs, they are a burden and a handicap to the student rather than a stimulation and inspiration. Personality and character are the attributes of good teachers no less than knowledge and mental power.

The service of industry to-day requires men of courage, character, force and inspiration, and to produce such men requires teachers of the same kind. That we have not more of them or enough of them is not altogether the fault of the teaching profession itself or of the colleges. The blame rests partly upon society and industry. It is not only that our good teachers are generally underpaid but, what is worse, they are also undervalued. To secure and hold men of force and distinction in our schools and colleges, it is necessary that they be compensated in proportion to the importance of the service they render. Moreover, they should have a standing in the public eye that accords with the significance of the responsibility that rests upon them, and this should be indicated by a wider opportunity and public demand that they function in the life of their community and their time. In the case of the teachers in the engineering colleges, they should be drawn more actively into contact with, and participation in the industrial life and made to feel more concretely that they have a definite rôle in industrial progress.

Finally, a fourth and most important basis for the readjustment of our engineering education and industrial requirements is the *closest coöperation between the industries and the schools.* It is obvious that neither the industries alone nor the schools alone can hope to solve the educational problem in this dynamic age of constant and rapid change. Only through close and continuous coöperation can the industries remedy the otherwise inevitable deficiencies of academic training and convey continuously to the schools information as to their needs and the trend of their development; and only in this way can the schools on their part plan to meet the changing industrial situation and approach more closely to the industrial requirements. With such a coöperative relationship, the schools can function effectively in providing the basic formal and the special vocational training upon which industry later can build; and adequate means for bridging the gap and softening the transition between school and industry could be worked out.

The many directions in which this coördination and cooperation are now being sought are familiar to you all, and I shall not attempt to discuss them at this time. Some of these experiments have worked out well and would appear to be of general usefulness; others, which have been developed under special conditions and to meet particular circumstances, have not had their general applicability fully tested as yet. It is clear, however, that no single or simple formula, device or system of coöperation is going completely to solve the problem of engineering education in relation to industry. The principle of coöperation must run through all stages and all aspects of the educational process, from the selection of the student material to the training of graduates. Its development must necessarily be a gradual process, largely experimental and adjusted to changing circumstances and particular needs. The engineering colleges, however, may be assured that American industry fully recognizes the need and responsibility for such coöperation which rests upon it, and that any methods which the educational institutions may de-

velop and which can demonstrate their effectiveness will meet with the hearty support of industry.

I cannot escape this conviction: the engineering college and industry will serve each other better and will more fully benefit their common object, the young man seeking entrance into industrial service by way of the school, when the teacher will consider, and be given the opportunity to consider, his task finished when he has helped to guide the young man in his initial stage of industrial life, and the industrial manager will consider, and be given the opportunity to consider likewise, that his task with the young man begins in the final stages of the latter's school career.

In conclusion, let me emphasize again that American industry needs to-day and will increasingly need in the future educated men in the best sense, men of high qualities of character, of broad knowledge and trained capacities. It looks increasingly to the engineering colleges for such men. To provide such men for the service of industry to society is the high responsibility which rests upon the schools and industry in common.

# WORK OF IOWA STATE COLLEGE COMMITTEE ON ENGINEERING EDUCATION RESEARCH.*

BY A. H. FULLER,

Professor of Civil Engineering, Iowa State College.

In a commencement address at Iowa State College in 1926, Chancellor H. S. Hadley of Washington University raised this question: "Why have we not made the progress in social and political lines that we have in material and scientific matters?" He also suggested the answer: "We have left them to solve themselves." He then propounded another question: "Can education do for government and law what it has done for science and industry?" His answer was that the greatest promise lies in the universities and colleges.

Perhaps he did not know that this Society was actively engaged in an educational investigation which included the human element and which would make material contributions to the ends he sought. A realization of this viewpoint grows as one studies the various papers and reports which have been issued.

The particular phases of the investigation which were undertaken by the Iowa State College Committee are:

## 1. Collection of Data from Undergraduates Concerning Themselves, their Background and their College Experiences.

In the spring of 1924, the Engineering Experiment Station undertook to collect certain personal data, statistics and opinions from its engineering students, former students and graduates. While the primary purpose was to secure exhaustive data bearing on the local situation, a sincere attempt was

* Presented at the 34th annual meeting of the Society for the Promotion of Engineering Education, The State University of Iowa, Iowa City, June 16–18, 1926.

made to have the work conform as nearly as possible to the national program of investigation along similar lines, sponsored by the Society for the Promotion of Engineering Education, which at that time was just getting under way.

The questions covered those in the national program as far as they were known at the time and included a number of others. The data secured as replies to the general questions are being included in the Director's report. This brief discussion will include only the specific ones which pertain to the undergraduate work and life.

From these data diagrams have been prepared as follows:

*Relating to Pre-College Experiences.*

1. Boyhood Hobbies.
2. High School Activities.
3. Influence of Brothers and Sisters.
4. Pre-College Employment. Short Job Employment in Early Boyhood.
5. Source of Student and Prior Education as Related to Scholastic Performance.

*Relating to Experiences in College.*

6. Time Spent on Campus Activities.
7. Declared Effect of Activities on College Work.
8. Extra-Curricula Activities as Related to Scholarship.
9. Time Spent on Outside Work.
10. Results of Work During College Year for Self-Support.
11. Nature of Work During College Year for Self-Support.
12. Declared Effect of Outside Work on College Work.
13. Declared Effect of Health on College Work.
14. Vacation Employment.
15. Difficulties in College.
16. Voluntary Reading.
17. Actual College Expenses.

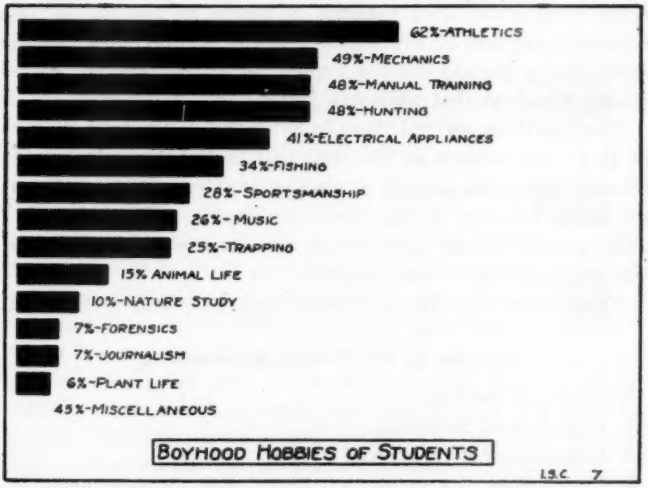
62%-ATHLETICS
49%-MECHANICS
48%-MANUAL TRAINING
48%-HUNTING
41%-ELECTRICAL APPLIANCES
34%-FISHING
28%-SPORTSMANSHIP
26%-MUSIC
25%-TRAPPING
15% ANIMAL LIFE
10%-NATURE STUDY
7%-FORENSICS
7%-JOURNALISM
6%-PLANT LIFE
45%-MISCELLANEOUS
BOYHOOD HOBBIES OF STUDENTS
I.S.C. 7

FIG. 1.

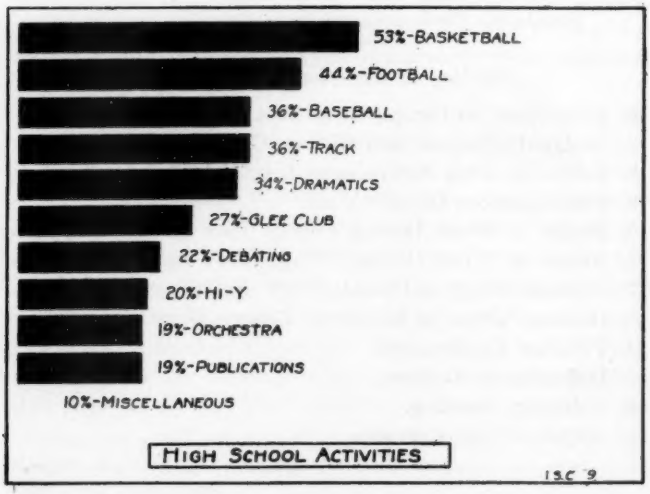
53%-BASKETBALL
44%-FOOTBALL
36%-BASEBALL
36%-TRACK
34%-DRAMATICS
27%-GLEE CLUB
22%-DEBATING
20%-HI-Y
19%-ORCHESTRA
19%-PUBLICATIONS
10%-MISCELLANEOUS
HIGH SCHOOL ACTIVITIES
I.S.C. 9

FIG. 2.

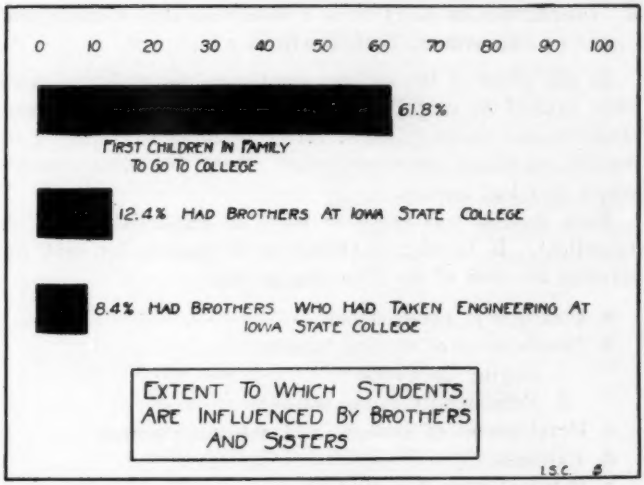
0 10 20 30 40 50 60 70 80 90 100
61.8%
FIRST CHILDREN IN FAMILY TO GO TO COLLEGE
12.4% HAD BROTHERS AT IOWA STATE COLLEGE
8.4% HAD BROTHERS WHO HAD TAKEN ENGINEERING AT IOWA STATE COLLEGE
EXTENT TO WHICH STUDENTS ARE INFLUENCED BY BROTHERS AND SISTERS
I.S.C.

FIG. 3.

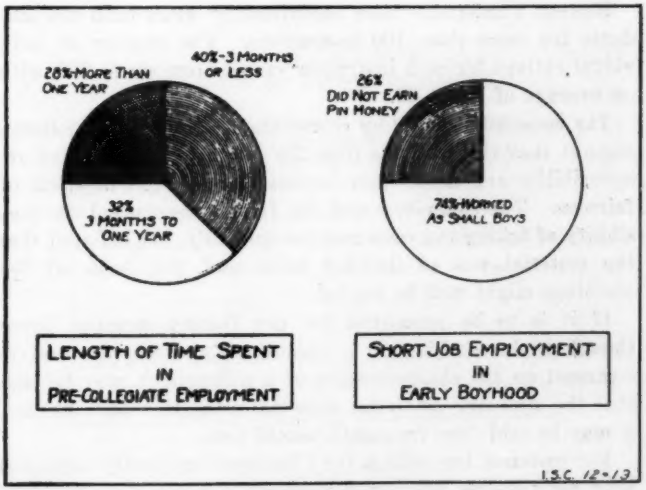
28%-MORE THAN ONE YEAR
40%-3 MONTHS OR LESS
32% 3 MONTHS TO ONE YEAR
LENGTH OF TIME SPENT IN PRE-COLLEGIATE EMPLOYMENT
26% DID NOT EARN PIN MONEY
74%-WORKED AS SMALL BOYS
SHORT JOB EMPLOYMENT IN EARLY BOYHOOD
I.S.C. 12-13

FIG. 4.

## 2. Collection of Data from Undergraduates Concerning Individual Members of the Faculty.

As one phase of the student questionnaires, undegraduates were invited to contribute a better understanding between students and faculty and to better teaching by replying to certain questions concerning each of the instructors under whom they had worked.

Each student was asked to make an impartial rating, A (excellent), B (good), C (fair), or D (poor), for each instructor for each of the following points:

*a.* Clearness of presentation.
*b.* Development of student interest.
    1. During the course.
    2. Permanently in the subject.
*c.* Development of thought and reasoning power.
*d.* Fairness.
*e.* Personal interest in student.
*f.* Remarks.

Ratings (unsigned) were submitted by more than 500 students for more than 100 instructors. The number of individual ratings for each instructor varied from six to 250, with an average of about 60.

The responses, including comments in the remarks column, suggest that the students took the matter as a delegated responsibility and made their replies in a thoughtful spirit of fairness. The committee and the faculty recognized the possibility of taking the responses too seriously, yet believed that the material was of decided value and that some of the warnings might well be heeded.

If it is to be permitted for one faculty member (even though he be working on a committee) to recognize and to comment on the characteristics of a colleague it may be said that the students' estimates were not altogether bad; in fact, it may be said they frequently aimed true.

For instance, low ratings for "fairness" evidently suggested long assignments and strict requirements for some teachers and favoritism or variable standards for others.

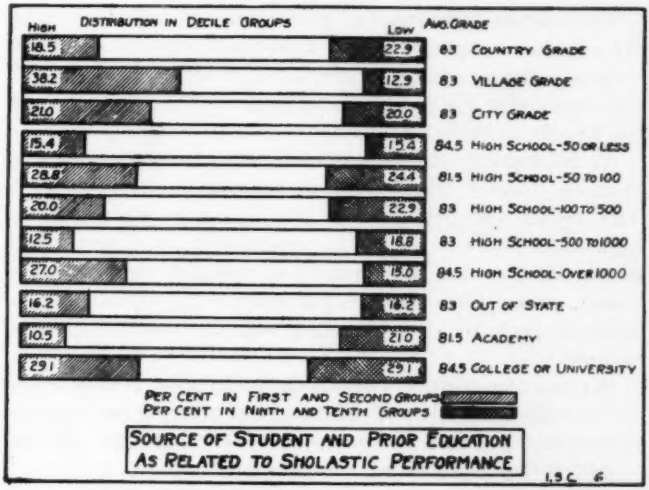
High
Distribution in Decile Groups
Low
Avg. Grade
18.5 22.9 83 Country Grade
38.2 12.9 83 Village Grade
21.0 20.0 83 City Grade
15.4 15.4 84.5 High School-50 or less
28.8 24.4 81.5 High School-50 to 100
20.0 22.9 83 High School-100 to 500
12.5 18.8 83 High School-500 to 1000
27.0 15.0 84.5 High School-Over 1000
16.2 16.2 83 Out of State
10.5 21.0 81.5 Academy
29.1 29.1 84.5 College or University
Per Cent in First and Second Groups
Per Cent in Ninth and Tenth Groups
Source of Student and Prior Education
As Related to Scholastic Performance
I.S.C. 6

FIG. 5.

## TIME SPENT ON CAMPUS ACTIVITIES

| HOURS PER WEEK | NUMBER OF STUDENTS | PER CENT |
|---|---|---|
| LESS THAN 5 | 133 | 44 |
| 5 TO 10 | 79 | 26 |
| MORE THAN 10 | 91 | 30 |
| TOTAL | 303 | 100 |

I.S.C. 13

FIG. 6.

Then, again, "clearness of presentation" evidently varied from concise statements of just what the thoughtful instructor wanted to say as a basis for discussion to such logical and full statements that the student could swallow them whole without the trouble of thinking.

An interesting relation existed between "clearness of presentation" and "development of thought." Occasionally a high rating was given in both but, as a rule, when one was high the other was low. This might lead to a very likely conclusion that the development of thought was dependent upon a presentation that was purposely restricted although it might be perfectly clear in stating what the instructor wished to state.

Perhaps the greatest value from the student replies rested in the self-examination of the instructor after he had seen the ratings and had read the comments concerning him. Several admitted they were eating "humble pie."

### 3. Collection of Data from Alumni (Including Non-graduates) Concerning Themselves, their Background, their College Life, and Subsequent Experience.

Tabulation and discussion of these data are not yet finished. Sufficient help will doubtless be available during the coming summer so that the studies may be completed before fall. Much good material has evidently been secured which covers pre-college days, the college course and subsequent experience.

### 4. A Study of the Five Fundamental and the Six Specific Questions Propounded by the Committee on Admissions and Eliminations.

The Iowa State College Committee admitted, at the outset, that the five fundamental questions were truly fundamental to a study of engineering education and that the six specific ones were also decidedly pertinent. The Committee recognized, too, that individual replies to most of them would vary tremendously and that a set of replies representing the composite views of a faculty would be most difficult to prepare.

In tackling the problem each member of the committee sub-

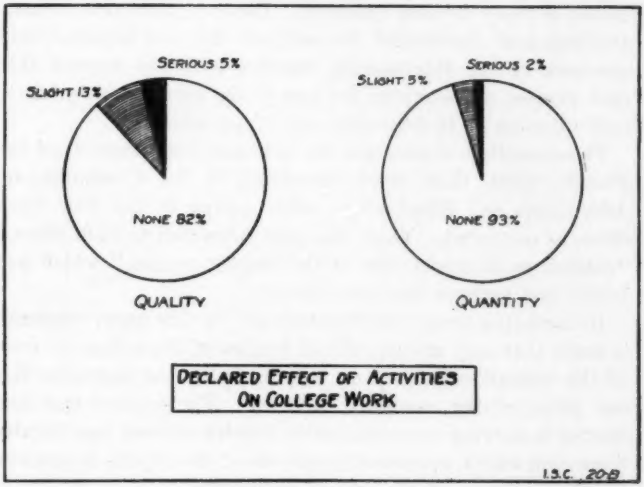
SERIOUS 5%
SLIGHT 13%
NONE 82%
QUALITY
SERIOUS 2%
SLIGHT 5%
NONE 93%
QUANTITY
DECLARED EFFECT OF ACTIVITIES ON COLLEGE WORK
I.S.C. 20-B

FIG. 7.

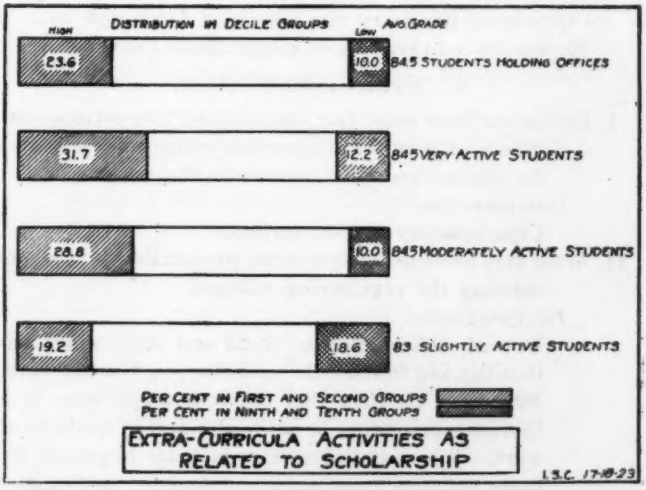
HIGH
DISTRIBUTION IN DECILE GROUPS
LOW
AVG GRADE
23.6
10.0
84.5 STUDENTS HOLDING OFFICES
31.7
12.2
84.5 VERY ACTIVE STUDENTS
28.8
10.0
84.5 MODERATELY ACTIVE STUDENTS
19.2
18.6
83 SLIGHTLY ACTIVE STUDENTS
PER CENT IN FIRST AND SECOND GROUPS
PER CENT IN NINTH AND TENTH GROUPS
EXTRA-CURRICULA ACTIVITIES AS RELATED TO SCHOLARSHIP
I.S.C. 17-B-23

FIG. 8.

mitted a reply to each question. These replies were mimeographed and distributed to each of the one hundred odd members of the Engineering Faculty with the request that each express a preference for one of the committee replies to each question or to formulate one of his own.

The committee replies and the vote and the comments of the Faculty upon them were submitted to the Committee on Admissions and Eliminations with a copy to the New York office, as requested. There was also submitted to each place a "committee interpretation of the faculty replies," which was boldly and perhaps tactlessly made.

In including these "interpretations" in this paper emphasis is made that they are not official replies of the college or even of the committee. They are given, rather, to illustrate this one phase of the committee activity. The project was successful in stirring up considerable faculty interest and faculty discussion which, apparently, was one of the objects in sending out the questions by the central committee.

### Committee Interpretation of Iowa State College Replies to Questions Raised in the Study of Admission and Elimination Statistics of Engineering Colleges.

#### *A. Fundamental Questions.*

I. Do the statistics show that unsatisfactory or serious conditions exist in the engineering colleges in respect to the elimination of students from their curricula?

*Interpretation:*

Unsatisfactory but not serious.

II. What may be done to improve the preparation of students entering the engineering colleges?

*Interpretation:*

Furnish information to State and high school authorities and to students regarding engineering work. Bring out the fact that the best preparation is a thorough grounding in principles and in methods of work. Where state laws may be made to permit, require entrance examinations at least in mathematics and English.

TIME SPENT ON OUTSIDE WORK

| CLASS | NUMBER OF STUDENTS | AVERAGE NO. OF HOURS PER WK. | | |
|---|---|---|---|---|
| | | 0 TO 10 | 10 TO 20 | OVER 20 |
| FRESHMAN | 214 | 32.2% | 26.2% | 41.6% |
| SOPHOMORE | 198 | 22.7 | 30.3 | 47.0 |
| JUNIOR | 141 | 22.1 | 30.7 | 47.2 |
| SENIOR | 66 | 24.3 | 28.8 | 46.9 |

I.S.C. 26-C

FIG. 9.

AMOUNT OF WORK DURING COLLEGE YEAR FOR SELF-SUPPORT

| CLASS | NUMBER OF STUDENTS | PROPORTION OF COLLEGE EXPENSES EARNED | | |
|---|---|---|---|---|
| | | LESS THAN $\frac{1}{4}$ | $\frac{1}{4}$ TO $\frac{1}{2}$ | $\frac{1}{2}$ TO FULL |
| FRESHMAN | 231 | 35.5% | 21.6% | 42.9% |
| SOPHOMORE | 205 | 32.2 | 19.5 | 48.3 |
| JUNIOR | 142 | 32.0 | 23.0 | 45.0 |
| SENIOR | 70 | 25.0 | 25.0 | 50.0 |

I.S.C. 26-A

FIG. 10.

III. What may be done to insure a higher grade of achievement among all the students of engineering colleges, thus lowering the per cent of elimination?

*Interpretation:*

Motivate and make more interesting the engineering subjects. Secure better teaching. Secure more personal faculty contact and more outside professional contact.

IV. Is there need of more restrictive measures in admitting students to engineering colleges?

*Interpretation:*

Yes. But more along the lines of being selective as to ability, personality, interest and character.

V. Is an injustice done a student to admit him to an engineering curriculum on the basis alone that he has graduated from a high school without additional selective methods being applied, when it is known that 60 per cent of the students so admitted fail to graduate and that 32 per cent of these are classed as scholastic failures?

*Interpretation:*

Yes.

### *B. Specific Questions which are Suggested by the Fundamental Ones.*

1. How can the engineering colleges exert a direct and effective influence on the preparatory schools in the way of securing greater emphasis and better instruction in the subjects of the high school curriculum which are fundamental to collegiate study? Other groups do exert such influence.

*Interpretation:*

In addition to the reply to Question II, furnish the schools the information upon which was based the statement that preparatory schools are deteriorating.

2. Are any of the following additional selective methods effective and practical?

NATURE OF WORK DURING COLLEGE YEAR FOR SELF-SUPPORT

| CLASS | NUMBER OF STUDENTS | NUMBER OF TIMES MENTIONED | | | | |
|---|---|---|---|---|---|---|
| | | UNSKILLED LABOR | SKILLED LABOR | DOMESTIC SERVICE | SELLING | MISCELLANEOUS |
| FRESHMAN | 243 | 39.1% | 8.2% | 42.7% | 9.4% | 14.4% |
| SOPHOMORE | 210 | 31.4% | 10.0% | 46.0% | 10.0% | 14.0% |
| JUNIOR | 149 | 22.0% | 13.3% | 43.3% | 15.3% | 22.0% |
| SENIOR | 69 | 24.6% | 27.3% | 27.3% | 11.6% | 21.6% |

I.S.C. 26-B

FIG. 11.

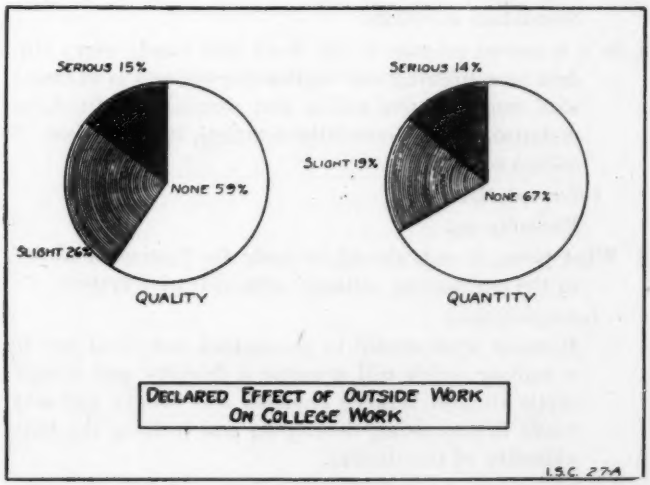


FIG. 12.

*Interpretation.*

(*a*) Pre-engineering collegiate work. No.
(*b*) Experience in industry. Doubtful.
(*c*) A probationary period of reviews and orientation. Doubtful.
(*d*) Entrance examinations in mathematics and English. Yes.
(*e*) Intelligence and aptitude tests. Yes.
(*f*) Personal interviews. Yes.

3. Should the "entrance with conditions" provision of engineering colleges be done away with entirely?

*Interpretation:*

No.

4. What may be done to bridge the gap between the high school and college so that the jar and shock will be less and the achievement of the first year greater?

*Interpretation:*

Get information to high school students as to what they may expect at college. Furnish a definite means of orientation at college.

5. Is it a correct premise to lay down that nearly every student now entering our engineering colleges is endowed with enough native ability and vocational aptitude to undertake and successfully complete the first year of college work?

*Interpretation:*

Probably not.

6. What place, if any, should be made for "personal work" in the engineering colleges' administrative system.

*Interpretation:*

Personal work should be encouraged and developed in a manner which will promote a friendly and sympathetic attitude between students and faculty and may result in expressing, developing and training the individuality of the student.

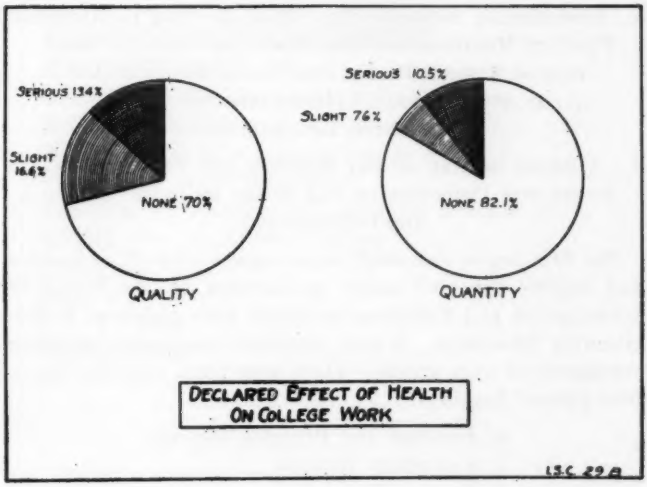


FIG. 13.

VACATION EMPLOYMENT.

| NATURE OF WORK | NUMBER OF STUDENTS | PER CENT |
|---|---|---|
| INDUSTRIAL | 289 | 64 |
| COMMERCIAL | 89 | 20 |
| FARMING | 126 | 28 |
| MISCELLANEOUS | 106 | 24 |

13C . 24

FIG. 14.

5. Discussions, through the Year, in the Engineering Faculty Meetings and Departmental Faculty Meetings of Various Papers and Topics Brought Out in the General Investigation of Engineering Education.

6. A Study of All of the Reports and Papers Prepared under the Direction of the Board of Investigation and Coördination.

The first step in this study was to make a list of all articles and reports prepared under or inspired by the Board of Investigation and Coördination which have appeared in Engineering Education. A short statement was made concerning the nature of each article. These were then classified under four general headings:

1. Forecast and Progress Reports.
2. Committee Reports.
3. Foreign Practice.
4. Miscellaneous.

Each member of the Committees on Engineering Education Research and Methods of Teaching was assigned certain of these articles to read and to abstract.

In view of the carefully prepared report which will be presented by the Director it would be presumptuous to attempt to summarize the available material. No such presumption will be made. Mention will be made, however, of a few of the findings which were given more or less emphasis in the local study.

The "Statement of Objectives and Outline of Procedure of the Investigation of Engineering Education" by Messrs. Scott, Bishop, and Wickenden in Engineering Education for January, 1925, and repeated by Professor Hammond at the 1925 Convention (Engr. Ed., Sept., 1925), gives a promising forecast for the final report. It includes the greater part of previous outlines and shows a continuity of purpose and a maturity of development. It suggests less emphasis than might be hoped upon one item under "Aims and Scope" as given by Mr.

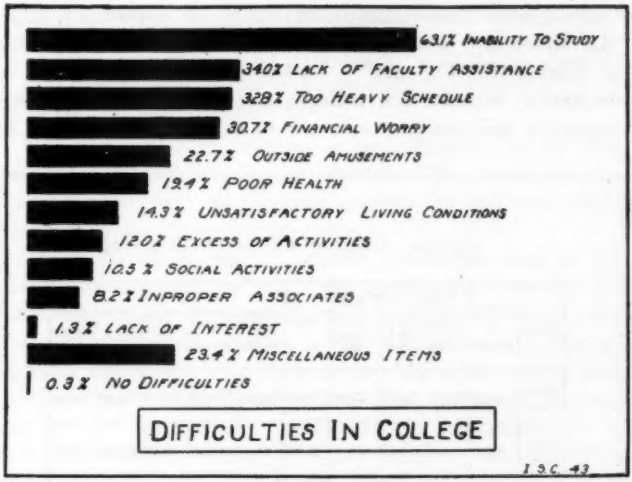


FIG. 15.

VOLUNTARY READING

| DAILY NEWS PAPERS | | | TECHNICAL LITERATURE | | |
|---|---|---|---|---|---|
| ISSUES PER WEEK | NUMBER OF STUDENTS | PER CENT | HOURS PER WEEK | NUMBER OF STUDENTS | PER CENT |
| 4 OR LESS | 197 | 34 | 4 OR LESS | 417 | 79 |
| 5 TO 7 | 289 | 50 | 4 TO 7 | 76 | 15 |
| MORE THAN 7 | 94 | 16 | MORE THAN 7 | 32 | 6 |
| TOTAL | 580 | 100 | TOTAL | 525 | 100 |

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FIG. 16.

Wickenden in ENGINEERING EDUCATION for September, 1924, "An Inventory of the Occupational Demands Confronting the Engineering Colleges." This subject is closely related to correlation between the colleges and industry. The Ames Committee believes this to be one of the important phases of

ACTUAL COLLEGE EXPENSES (DOLLARS)

| YEAR | NUMBER OF ANSWERS | TOTAL EXPENSE | | | FEES (Av) | BOOKS & SUPPLIES (Av) | BOARD & ROOM (Av) | AMUSEMENTS (Av) | CLOTHING (Av) | MISCELLANEOUS (Av) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | MINIMUM | MAXIMUM | AVERAGE | | | | | | |
| FRESHMAN | 480 | $145. | $1200. | $602 | $75.50 | $38.05 | $309.00 | $47.10 | $72.00 | $56.46 |
| SOPHOMORE | 341 | 125. | 1500. | 644 | 76.70 | 48.40 | 325.40 | 53.80 | 83.50 | 59.10 |
| JUNIOR | 222 | 200 | 2300. | 679. | 75.40 | 53.20 | 324.00 | 68.10 | 84.70 | 69.00 |
| SENIOR | 120 | 203. | 1300. | 723. | 88.00 | 58.00 | 336.00 | 80.00 | 92.00 | 73.00 |

I.S.C. 41

FIG. 17.

the whole "Investigation and Coördination" and trusts the early emphasis upon it will be maintained and carried even beyond the limits of the excellent paper by Mr. Jewett in ENGINEERING EDUCATION for February, 1925.

In the "Remarks of the Associate Director at the 1925 Convention" (ENGINEERING EDUCATION, September, 1925), Professor Hammond refers to high school preparation as follows:

"The most serious deficiencies appear to be in the knowledge of the fundamental principles of elementary mathematics and English. Students appear to have little idea of thoroughness and very little self-reliance. One committee puts the matter

aptly by stating that students appear to have been taught to solve easy problems by imitative methods. It must be remembered that this condition holds in spite of the fact that a large proportion of our students come from among the best graduates of the high schools."

The Committee on Admission and Elimination of Engineering Students says, in ENGINEERING EDUCATION for September, 1925, that high school preparation has been deteriorating during the past ten years.

The challenge contained in these statements must be met. High school authorities may take notice and they may not. They may recognize unsatisfactory conditions and they may not. In any event, changes in the high school situation will be made but slowly. In the meantime the colleges must study raw material as well as curricula. They must seek to correct any bad habits and any deficiencies in preparation in the entering students. The preliminary reports of Director Wickenden and his colleagues suggest much efficient help in the solution.

In closing I would say the brief studies of the Ames Committee suggest that thorough studies of the final report will contribute much to the ideals suggested by Chancellor Hadley and, in general, will yield large dividends.

# REPORTS OF FACULTY COMMITTEES.*

UNIVERSITY OF MICHIGAN.

BY W. C. HOAD.

The College of Engineering of the University of Michigan for three years past has been seriously engaged in a study of how to bring the work of the College into more complete harmony with the real requirements of the engineering profession and especially how best to meet the needs of the young men who present themselves for entrance into this profession through the College. During the past two years this College has been coöperating whole-heartedly with the other schools and colleges of the country in the great investigation of engineering education being conducted by the Board of Investigation and Coördination, whose report is to be heard at this meeting.

For at least a year the faculty at the University of Michigan has in a certain sense been marking time, waiting for the final report of the Board, ready to march ahead with any concerted and well-ordered advance movement. Its representatives come to Iowa City, therefore, with a clear understanding of the far-reaching importance of the forthcoming report of the Board and with a deep sense of the significance of the present meeting of the Society as setting the pace for probably the next teaching generation.

During the past year the faculty at Ann Arbor has reviewed and discussed the general problem from many angles and in many ways. In all the routine adjustments of courses and curricula, and of relationships with Junior Colleges and other colleges in the state, and of other like matters that have come up for consideration—these being in the nature of

* Presented at the 34th annual meeting of the Society for the Promotion of Engineering Education, The State University of Iowa, Iowa City, June 16–18, 1926.

normal activities of operation and maintenance—always this impending forward movement has been in mind and has been the background for most of the discussions and the determining factor in all major decisions.

Especially, however, during the second semester there has been a special series of seven or eight faculty meetings arranged solely for the discussion of the general question of improving engineering education at Michigan. At these faculty meetings reports were heard from four sub-committees of the faculty's general Committee on the Study of Engineering Education, which had been in operation for more than three years. These sub-committees correspond in great degree to the subdivision of the investigational work in all the colleges, being as follows:

1. On Admissions and Eliminations,
2. On the Entering Student,
3. On Teaching Personnel,
4. On Graduates.

The reports of these sub-committees consisted largely in a review and consideration of our own particular data, but projected against the background of the data collected from all the colleges and set forth in the published reports of the general sub-committees of the Board of Investigation and Coordination. The emphasis was laid upon the facts pertaining to our own institution, however, as these facts had been disclosed in the studies of the past two or three years.

The discussion of the questions brought forward for consideration by these four reports was active and general throughout the faculty, all departments and all grades of rank finding adequate expression. As a final outcome for the present the faculty adopted a group of resolutions indicating what appeared to be the general lines along which engineering education at the University of Michigan might best be improved. The intention is that the ways and means of accomplishing this improvement will be worked out after the meeting here in Iowa City. The resolutions adopted are as follows:

WHEREAS the investigation of engineering education, in which our local committee is a coöperative unit, was prompted by the aspiration "to develop, broaden and enrich engineering education"; and

WHEREAS a first obligation in meeting the insistent demand of the engineering profession for better men, more broadly trained, is to perfect the selective methods by which the college shall secure a larger percentage of men with genuine aptitude for professional training; and

WHEREAS vocational guidance becomes not only a means of eliminating the present waste, due to the large numbers of students who enter the Engineering College without intelligent motive, but also an obligation to the profession which holds us responsible for the choice and training of the engineers of the future;

Therefore, *be it resolved:*

1. That the College of Engineering find some effective means of placing before high school students a clearer, more comprehensive and better proportioned picture of what engineering is, and what its relationships are to the problems of the present and future civilization of the world.

2. That the Freshman Assembly be so modified as to include in its objectives the following:

   (*a*) to bring before the student at an earlier date than has heretofore been customary accurate and well ordered information concerning the several fields of engineering represented by our curricula;

   (*b*) to show more clearly and convincingly the fundamental dependence of sound engineering upon science, the increasing importance of human relationships in engineering, and the high value of linguistic training, and thus to broaden and deepen the student's interest in the non-technical elements of his curriculum; and finally

   (*c*) to present to the student some of the important human problems of the past and of the present, as a means of cultivating his intelligent interest in and ability to think on extra-engineering matters.

3. That, as a faculty, we favor the proposed Freshman Week as an additional effective means of bridging the present gap between high school and college.

WHEREAS the effectiveness of any curriculum of studies depends largely on the character of the teaching staff and its esprit de corps;

Therefore, *be it resolved:*

1. That the qualities on the basis of which new members of the faculty shall be engaged and advancements to higher rank be made shall be, in the order of their importance, as follows:
   (*a*) Scholarship, particularly in the subject of specialization.
   (*b*) Ability as a teacher.
   (*c*) High professional standing.
   (*d*) Interest in and familiarity with the humanities.
2. That it be the administrative policy of these colleges to give every opportunity to teachers on the faculty for the continued development of these qualifications, and that promotion purely on the basis of expediency be discouraged.
3. That, as a means of cultivating acquaintance among the members of the faculty, there shall be a series of group social meetings, so arranged that each member of the faculty shall have the opportunity to meet every other member at least once during the year.
4. Further, that the custom already established in several departments, of having regular staff meetings and staff luncheons, be made more general, and that all departments be urged to hold such meetings at regular intervals.
5. That a program of faculty meetings be prepared for the year at which routine business shall be limited, and the time be largely devoted to the discussion of educational and administrative problems.

WHEREAS the demand of both recent and older graduates, as evidenced by the replies to the questionnaires returned by graduates of this college, is quite insistent for men more broadly trained and better fitted to serve, not only as engineers, but as liberal-minded members of society; and

WHEREAS the suggestions of a lengthened course and a more liberal curriculum are so generally made;

Therefore, *be it resolved:*

1. That we favor the lengthening of the period of instruction in our engineering colleges beyond four years.

2. That in the revised curriculum increased emphasis be placed upon the basic courses in engineering, which are common to all the departments of specialization, and upon the fundamental technical courses in the specialized departments.
3. That changes be made in the curriculum to provide for more studies which will be designed to develop the student's capacity to understand life, broaden his outlook on life and enrich his enjoyment of life, and which, when joined to specialized training, will tend to make him more useful to society.

UNIVERSITY OF WASHINGTON.

BY E. R. WILCOX.

It may seem trite to say that before setting out to attain a goal one should know what and where the goal is; yet there is probably no one point in engineering education on which there is more extensive difference of opinion than on its objective. It is not the purpose of this paper to enter into controversy over whether the prospective engineer should have more training to fit him fully for the business side of engineering; or whether he should have more cultural training to fit him to mingle with his fellow men easily; or whether he should have more work of a practical nature so that he can step into engineering organizations with less breaking in; or to argue on many other points of view which we frequently see concerning the objectives of engineering education.

It does seem desirable here, however, that a point of view be taken and an objective defined in order to obtain a proper perspective of what follows. Broadly stated, the objective here considered and particularly applied to the freshman year is the selection of students who can absorb sufficient fundamental knowledge and will take the necessary character training and mental training to permit the men eventually to take their places as useful members of that part of society known as the engineering profession. The selection of such students and the beginning of these processes should be the work of the first year.

What follows is intended only as supplementary to several articles and reports which are referred to at the conclusion of this paper, and as observations and discussion on studies now being made.

## SELECTION PROCESSES.

The writer having had training and experience in metallurgical engineering, finds it easy to approach the first-year

problem by analogy, though somewhat loose, between it and the production of metals. There comes first the consideration of the raw material; then the treatment of this material by grading, separating, and refining; and finally the acceptability of the resulting product.

No concern handling raw material would think of putting it into the steps of manufacturing without careful sampling and analysis or assaying. We know by analysis there are various kinds and grades of iron ore, and that these different variations require widely different methods of treatment to obtain commercially satisfactory products. When it comes to human materials, this same condition is true in the superlative degree. The question is raised as to how we are meeting these facts in the design of our present and future engineering educational processes. It is not intended to convey the idea that human beings can be handled and treated mechanically the same as inanimate material, but there is much that has been worked out with the latter that can measurably assist us in our problems with the former.

It is claimed by some that the first-year students who enter our engineering colleges have been subjected to a marked process of selection. The recent studies of the S. P. E. E. investigation tend to support this claim. But it is our experience at Washington, a state institution with comparatively high entrance requirements, that the selection or grading of the engineering material received is still a long way from all that could be desired; and we are convinced that this is the case in most other institutions. A census of about 250 entering students last fall showed that 92 per cent of them came from accredited high schools and that 10 per cent of these men had *A* grades in three fourths or more of their high school subjects.

A study of these honor men from high school is in progress to see how their university records compare with their previous records. A special effort is being made to arouse their interest in a broader training and education than is obtained ordinarily in a four-year engineering course, either by carry-

ing extra hours or by taking one or more additional quarters of work. The Freshman Advisor is doing this work at the request of the Dean of Men. It is interesting to note in passing that there are always several high school honor men each year who have considerable trouble with their first quarter of university work; the reason usually given by them is, "We didn't have to work to get our grades before." Some would consider this an excellent argument for sectioning classes in the high schools on the basis of ability.

### Use of Placement Tests for Sectioning.

Since we find a variation in ability of our entering students which closely approximates the normal probability or Gaussian curve, we have adopted placement tests in physics and mathematics, giving them at the beginning of the quarter as a means of preliminary sampling and grading. On the basis of the scores in the tests, the men are resectioned into first, second, third, and fourth sections in two of the first-quarter engineering subjects, engineering drawing and engineering problems. In the first-quarter mathematics, trigonometry, the men are given a test in high-school algebra after a two-week review; and all those receiving unsatisfactory grades are transferred for the remainder of the quarter to a tutorial section for high-school algebra without credit. The number of those failing this test has averaged about 15 per cent of those registered for trigonometry. About 34 per cent of those entering engineering last fall were deficient in the mathematics requirements; this includes those with high-school deficiencies as well as those failing the review test. (The high-school mathematics requirements are three semesters of algebra and three semesters of geometry.) A further study of these cases has shown that the man deficient in his mathematics requirements is three times as liable to a failure in some subject his first quarter as the man who is not deficient. In freshman chemistry the men are not resectioned on the basis of grades until the second quarter, due to the difficulty of reassigning laboratory space. However, separate sections

are made up depending upon whether the student has or has not had high-school chemistry. The scores made in an intelligence test given by the department of psychology to all entering students are used by the Freshman Advisor as an influencing factor in consideration of certain cases.

Resectioning in engineering problems on the basis of the Iowa Placement Tests in physics aptitude and training was found very satisfactory for the first quarter, particularly for the first and fourth sections. The same was true of the resectioning in engineering drawing, based on the mathematics aptitude and training tests. These statements are based on the judgment of the nine engineering instructors who taught the courses; for the correlation figures on the test scores and grades have not yet been worked out for this year. The following are the correlation figures worked out for the first-quarter freshman grades and scores made in the Iowa Placement Tests, which were given at the beginning of the second quarter last year:

*Coefficients of Correlation*

| *Clearer Statement of Tests* | CA | MA | EA | CT | MT | ET | CG | MG | UW | GE-11 | GE-1 | Ave. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CA | | 63 | 38 | 58 | 68 | 51 | 46 | 43 | 48 | 63 | 64 | 54.2 |
| MA | | | 47 | 57 | 64 | 61 | 44 | 35 | 61 | 68 | 38 | 52.8 |
| EA | | | | 25 | 35 | 59 | 08 | 11 | 60 | 75 | 12 | 35.6 |
| CT | | | | | 78 | 43 | 63 | 27 | 43 | 62 | 43 | 51.3 |
| MT | | | | | | 37 | 55 | 58 | 47 | 64 | 50 | 51.8 |
| ET | | | | | | | 25 | 19 | 56 | 31 | 27 | 31.6 |
| CG | | | | | | | | 56 | 34 | 66 | 53 | 52.3 |
| MG | | | | | | | | | 17 | 68 | 42 | 42.3 |
| UW | | | | | | | | | | 31 | 23 | 27.0 |
| GE-11 | | | | | | | | | | | 74 | 74.0 |
| Average | 63 | 42.5 | 46.6 | 61.2 | 50.2 | 40.7 | 35.6 | 45.8 | 58.7 | 42.6 | | |

CA = Chemistry Aptitude; MA = Mathematics Aptitude; EA = English Aptitude; CT = Chemistry Training; MT =

Mathematics Training; ET = English Training; CG = Chemistry Grade; MG = Mathematics Grade; UW = University Intelligence Percentile, Revised; GE–11 = Engineering Problems rank; GE–1 = Engineering Drawing rank.

Correlation Formula

$$\frac{xy}{\sqrt{x^2\,y^2}} = r,$$

75 identical cases for all Iowa Tests, the chemistry grades, the mathematics grades, and the I.T. grades; 72 identical cases of the above 75 for GE 1 and GE 11.

The marks used in getting the correlations were the raw scores of the Iowa Placement Tests; the percentile ranking was secured in

Chem. grades (based on 6 exam. grades and lab. reports).
Math. grades (by classes), U. of W. Revised I.T.
GE 1 and GE 11 (by rank based on daily grades).

Of course there are always a few misplacements in each group of sections, but these are adjusted as soon as found by mutual transfer between sections. At the end of each four-week period, the top and bottom fourth of each section, based on the total daily grades for that period, are arbitrarily transferred up and down respectively. This gives each instructor an opportunity to compare the average of his section with the best of the section below and the poorest of the section above; so that when there is any question of a man's proper place, he is subjected to the opinion of two or three, sometimes four, instructors in the course of a quarter. Such procedure can be followed without detriment and with possibility of considerable benefit to the student because the basic material in each class is kept closely coördinated by short weekly conferences of all instructors in each course. The additional material for the better sections is obtained by going further into the subject rather than by covering more subject matter. This method is particularly adapted to first-year work where the content of the courses deals with fundamental concepts

and laws. From a preliminary examination of the data available, it is apparent that the first section accomplished from three to four times the quantity of work done by the fourth section, and of course of far better quality.

Due to the fact that a shift from one section to another is possible at any time upon proper showing, no serious complaints have been heard from any of the students, while many of them speak highly of the system. They seem to consider that it is very fair in respect to grades earned and advantageous to their individual progress. The relative standing of the men in each class is posted at the beginning of each week so that no one is ever in doubt about the instructor's estimate of his work.

### Character Estimates.

The classification methods just mentioned concern only the mental capacity and the acquired knowledge of the individual, or as we might say, the classification of material as to size only. There remains still another important factor in our grading, and that is what the metallurgist would call classification in respect to weight or value. This could be termed, when applied analogously to the student, grading as to character. The metallurgist knows that it is usually advantageous to classify as to size first, so he screens his material. After like sizes are obtained, he then classifies as to weight by means of jigs, tables, etc. It is the need of this later grading which educators have perhaps not seen so clearly, at least not as clearly as the former; or if the need has been realized, they have lacked the resources, the courage, or the machinery to tackle the job in a scientific way. Recent studies in the field of applied psychology in connection with management and personnel work have given us some idea of available machinery. It is encouraging to see that the need of the work is becoming more generally recognized.

We have endeavored to start this work in a small way. Near the end of each quarter each instructor in the problems and drawing work is asked to turn in on a card provided for the purpose, an estimate of the following qualities for each one of his students:

1. Attitude (open-minded, interested, alert, making an effort, coöperative, grouchy).
2. Reliability (honesty, promptness, follows instructions, always has work ready when due, unexcused absences).
3. Initiative (self-starter, not continually asking for help, self-reliant).
4. Personality (bearing, appearance; how does he impress you?).
5. Judgment (common sense, profits by mistakes, ability to draw reasonable conclusions from facts at hand).

Each man is graded on the basis of four points in each quality. In grading each quality the instructor is asked to select a man who in his opinion belongs unquestionably in the first, second, third, and fourth quarter of all the students, and to rate all his men by comparison with these standard men. This is similar to the army method. Each regular freshman is thus given at least six ratings during the year. On last year's men it was surprising how closely the ratings of the different instructors agreed. These ratings are recorded on a permanent record card which is kept in the Freshman Advisor's office.

These cards are intended as a step in the establishment of a permanent four-year record in the Dean's office. These records are to be used in placement work. A copy of both sides of the card is here shown:

Name..... .....
(Last name first) Prep School—Town & State

Permanent Address..... ..... .....
Year Graduated Age Now

Nature of Previous Paid Employment with length of service in months:

.....

.....

.....

P. T. Scores I. Q. C.E. 1 2 13 11 12 21

Chem. 1 2 3 21 22 23

Math. 1 2 51 52 53

Name..... .....
(Last name first) (Date)

Grade Points—4, Excellent; 3, Good; 2, Fair; 1, Poor

1—Attitude ..... Remarks:

2—Reliability .....

3—Initiative .....

4—Personality .....

5—Judgment .....

The cards are passed out to the students at the beginning of the year, and they are asked to fill in all the information which they can. This gives them opportunity to see the form of record which is kept. Pertinent facts as obtained from conference with the student are noted on the card, and it is hoped in the near future to secure a stamp size picture of each man for his record.

The Freshman Advisor has found these records to be of great value in dealing with the student. Each individual's card is shown to him if he so desires. The student realizes that the advice given is based on some facts and is thus encouraged to put all the facts in his possession on the table for consideration. With these data before him the Advisor feels reasonably sure of his ground in making his recommendations on petitions for reinstatement of students dropped for poor work. By the end of the second or third quarter, advice as to whether the student should continue in engineering can be given with at least some assurance of fairness and probability of correctness.

### Administrative Adjustment for the Work.

This year the freshman work which is common to all departments of engineering was made a separate division in the College known as the department of General Engineering. The Freshman Advisor was appointed executive officer of this

department. A time allowance of one half of the normal teaching load is granted by the university administration for his work. The work is departmental administration, student personnel work, and vocational guidance through class work and individual conference. The Advisor might be called a coördinator or laisson officer for the instructors, the first-year courses, and the university administration; also for the first-year student, his difficulties and problems, and the administration. Recently the parents have appeared as an added factor.

The time allowed for this work does not in any way represent the proportion of the Advisor's time needed and spent on it. In the opinion of the writer, however, such an officer should not lose touch with the class work, one class each quarter being the ideal amount of instructional work that should be carried.

The weekly conferences of the instructors, where improvement in method and content of the courses are discussed, and the progress of the students studied, have proved surprisingly valuable in several respects: The courses are kept continually up-to-date and progressive; valuable training and insight are given to the new instructors, for the ideal is to have the new instructors of all engineering departments come from those who have been teaching freshman work; the Advisor is kept in touch with work of the various students through the discussions which naturally arise between different instructors having the same students; the students are assured a fair placement in their proper sections; and finally, the weekly work is kept carefully coördinated.

The two- and three-hour class periods give the engineering instructor excellent opportunity to discuss with each student his individual problems. Most of the instructors are men who have been out of college only from two to six years and who still retain a sympathetic understanding of the student's needs and viewpoint. The individual conference time of the Freshman Advisor is naturally given in large proportion to the especially gifted student and the student who is in particular difficulty. Except in special cases these conferences are not

compulsory, although each first-year student must now have his schedule of classes and hours approved each quarter by the Advisor. This is made possible by the system of pre-registration now in effect. The student first presents his tentative schedule to one of his instructors for approval as to detail, and then comes to the Freshman Advisor for final O. K. This gives the Advisor opportunity to meet each student at least three times during his freshman year. A shelf of books on the different lines of engineering is another factor which brings the student into the office. These books are loaned for short periods to anyone interested.

### Vocational Study by the Freshman.

A scheme was tried this year for getting the student interested in studying himself, which in our opinion proved very successful: An assignment in the first-quarter problems course was given to make an outline analysis of the job which the student expects to enter upon graduation, or if he has not chosen his department, to outline a job which particularly appeals to him. A suggested outline was given the student to lead him to find the points of special difference between his job and others of somewhat similar nature, the training and qualifications particularly desirable, the entrance conditions to be expected, and the later conditions and opportunities that should obtain. Some references to books and articles were given and the student told to list the sources of his facts at the end of his outline. This assignment was made following a talk to the men on "Engineering as a Career" by the Dean of the College. Near the end of the quarter these papers were called for and several of them read before the class and discussed. This work made a very favorable appeal to the student and in most cases brought to his attention his surprising lack of facts concerning his chosen career—exactly 80 per cent of them had already determined upon the branch of work which they wished to follow. A census on this point was taken early in the year and a comparison of this census with the elections of course at the beginning of the sophomore year

is expected to give some useful figures on the need of such vocational work and some measure of its effectiveness. During the second quarter a series of short talks by members of the different departments serves to keep the idea of "where he is headed and why" alive in the student's mind.

### The Misfits.

This brings us to another of the real problems connected with the production of a potential engineer: the problem of handling the rejects or the material which cannot be converted profitably into the product desired. It has been an axiom in ore dressing that the earlier in the mill this extraneous material can be eliminated, the more effective and cheaper the process will become. The elimination of waste, the idea that as little as possible of time or material should be wasted, is very popular, and rightly so, among engineers at present. The idea of early classification is aimed to obtain this reduction in waste. It is our experience that a considerable percentage of the material which we receive is not suitable for the production of engineers. It is generally agreed that but few individuals are worthless, but many are of far less value as engineers than they would be as other kinds of producers in society. In the case of our students it is practically impossible to determine who these misfits are by examination upon entrance; nevertheless they are there; and the longer they continue in the course, the greater the cost to the institution, and the greater the loss to the individual. It should be fairly evident that the segregation cannot be justly and efficiently made on the basis of first-year grades alone—the process is too automatic.

As an illustration of what is meant, there is the example of two large and well-known mining concerns: They both developed large deposits of low grade ore, valued at approximately only one dollar per ton. They depended upon large volume of output to make their profit. Both milled all of their ore just as it came from the mine, for a time. Neither made any profit. Then one concern found that by hand-pick-

ing their ore to eliminate the easily apparent very low grade material early in the milling process, they would be enabled to make an operating profit. This was a new idea in low-grade large quantity production. The other company could not do this and lost their investment. We believe that there should be more "hand-picking" in our educational process; and moreover, that this can be done without abnormal increase in cost if the improvement in product is considered of any value.

### Measurement of Results.

In order to know the effectiveness of our methods and the resultant quality of our product, numerous control measurements are needed. And here we find great difficulty—for who can measure the success of a man? We believe that something can be done in the matter by making use of measurements which are possible to obtain. A problem which is being attempted this year is to find a correlation, if there is any, between deficiencies in mathematics and failures in engineering work. The large percentage of mathematics deficiencies was previously noted. The matter of the quantity of outside work carried in addition to the scholastic schedule is known to have a direct bearing on the item of poor work in many cases. Because of this the student is required to note the actual hour of outside work on his registration blank and is not permitted to do more than eight hours of such work per week in addition to a regular fifteen-hour scholastic schedule except in rare cases. Forty-three per cent of our freshmen this year are doing paid outside work, varying from three hours per week to fifty-four hours per week. An attempt is being made to find a definite relation between the amount of outside work carried and the grades earned.

As a measure of what is being accomplished in the first-year work, the following table is given, based on a study of one hundred eighty four students who finished the first quarter in the College in the fall of 1924. It may be looked upon as an assay sheet of the first-year product:

ATTENDANCE STUDY FOR FOUR QUARTERS, FALL 1924 TO FALL 1925 INCLUSIVE.

| Quartiles on Basis of Pooled 1st Qtr. Grades | Percentages Based on No. of Men Finishing 1st Qtr. | | | | Quartiles on Basis of Pooled Test Scores 6 Iowa P.T., 1 U. of W. I. T. | Percentages Based on No. of Men Finishing 1st Qtr. | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1st qtr. | 2d qtr. | 3d qtr. | 4th qtr. | | 1st qtr. | 2d qtr. | 3d qtr. | 4th qtr. |
| 1st qtle..... | 100 | 98 | 86 | 71 | 1st qtle..... | 100 | 96 | 72 | 67 |
| 2d qtle. ..... | 100 | 88 | 67 | 33 | 2d qtle..... | 100 | 95 | 64 | 43 |
| 3d qtle..... | 100 | 82 | 46 | 36 | 3d qtle..... | 100 | 75 | 43 | 30 |
| 4th qtle..... | 100 | 60 | 18 | 13 | 4th qtle..... | 100 | 70 | 46 | 24 |
| Entire group..... | 100 | 83 | 55 | 39 | Entire group..... | 100 | 84 | 56 | 40 |

The total percentages given do not exactly represent the actual drop in enrollment for succeeding quarters because they are based on one unselected group of entering freshmen. Men are continually returning who have been out for one or more quarters, so that the actual total enrollment percentages are about 100, 85, 60, and 50 for the respective quarters. The encouraging thing about the figures is the high percentage of the first one fourth of the class who continue. The point on which we intend to concentrate study is the high loss in the second fourth. See Graphs A and B.

The foregoing is a brief review of the present methods of classification in use at Washington. They are set down in the hope that they may call forth comment and discussion which will suggest changes and improvements in the light of the experience of others. As far as possible the above outlined ideas are kept in mind in connection with all the first-year work; but the problems, drawing, and surveying courses, which are directly in the Engineering College and taught by engineers, lend themselves particularly well to this purpose. It is felt that the success of this work is due largely to the effective way in which these courses are handled. A description of the courses, together with a summary of the objects sought and methods used, has been presented in various papers (see Nos. 1, 4, 5, 9, and 10 of bibliography), so they

will not be further discussed here, other than to say that with the mathematics and chemistry courses they are the machinery which is supplied to do the initial concentrating and refining of the raw material.

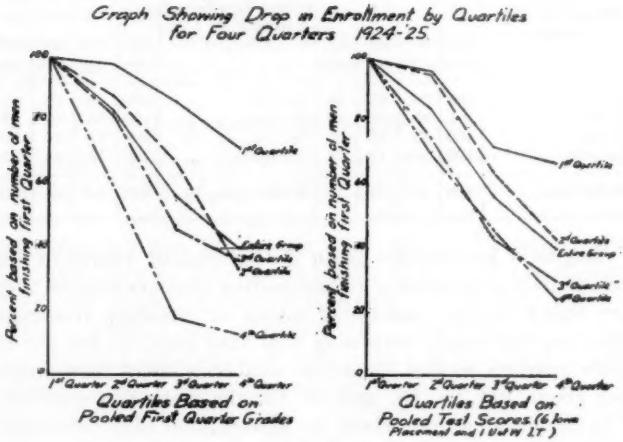

Graph Showing Drop in Enrollment by Quartiles for Four Quarters 1924-25
Percent based on number at men finishing first Quarter
1st Quarter 2nd Quarter 3rd Quarter 4th Quarter
Quartiles Based on Pooled First Quarter Grades
Quartiles Based on Pooled Test Scores (6 from Placement and IUSH LT)

FIG. 1.

In conclusion we invite discussion on the following topics:

1. Means of obtaining closer coöperation between high school and engineering college.
2. Methods of obtaining closer and more effective contact with our entering students.
3. Methods of accurate evaluation of these students.
4. Systems of recording the data obtained.

BIBLIOGRAPHY.

1. "Mechanics of Engineering at the University of Washington," by W. E. Duckering. Engineering Education, Vol. VII, No. 9, 1917.
2. "A Study of Engineering Education," by Charles Riborg Mann, The Carnegie Foundation for the Advancement of Teaching, Bulletin No. 11, 1918.
3. Annual Report of the General Education Board, 1918–1919.

4. "Comments on the Course in Engineering Mechanics at the Engineer School, Camp Humphreys, Va.," by W. E. Duckering, Published by the Engineer School, U. S. A., March 30, 1919.
5. "Problem Method at Engineering School, Camp Humphreys," by C. C. More and W. E. Duckering, Engineering Education, October, 1919.
6. "On Motivation," by W. K. Hatt, Engineering Education, Vol. X, No. 6, 1920.
7. "Sectioning on the Basis of Ability," by C. E. Seashore. Bulletin of American Association of University Professors, Vol. IX, No. 6, Oct., 1923.
8. "Recognition of the Individual," by C. E. Seashore. Engineering Education, Vol. XV, No. 1, Sept., 1924.
9. "The Engineering Problems Courses at the University of Washington and Iowa State College," by Forest C. Dana. Engineering Education, Vol. XV, No. 2, Oct., 1924.
10. "The Freshman," by C. L. White. Engineering Education, May, 1924.
11. "Personnel Work at the University of Maine," by W. J. Creamer, Jr. Engineering Education, Vol. XVI, No. 4, 1925.

## Lehigh University.

F. V. LARKIN.

Three times during the last six years the faculty of Lehigh University has undertaken a complete revision of the engineering curricula. The first attempt, carried on with infinite pains, elaboration and dignity, resulted in the curriculum which has been in operation since that time. The work was well done. The movement was significant, but no uniformity resulted. Foreign language remained; the professional degree remained, and no indication of a break at the end of the Sophomer year was manifested. Three significant movements were inaugurated: first, there was recognized a need for "more economics and better English"; second, a long stand requirement of two years of foreign language was reduced to a one-year requirement; and third, military science and tactics was adopted.

The second attempt directed at uniformity brought forth still more elaborate studies and committee reports, many of which were of outstanding merit. Its single, tangible, absurd result was uniformity for the first term of the Freshman year.

With this experience of substantial work, if not accomplishment as a background, and with a logical well defended request for a change in one individual curriculum before it, for the third time the faculty disposed of the matter by placing it in the hands of the Engineering Council so-called, for study and report.

The work of this Council adopted by the faculty at the April meeting may be summarized as follows:

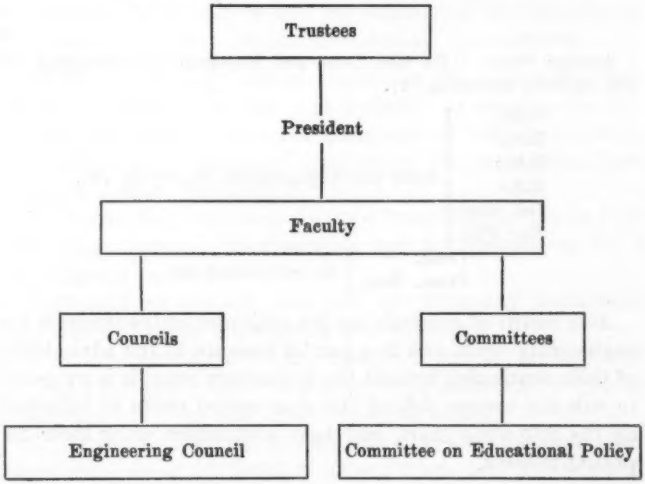
Engineering Curricula at Lehigh University.

| –1926. | 1926–. |
|---|---|
| 1. No uniformity. | 1. Uniformity for practically 2 years. |
| 2. Foreign Language—required. | 2. Foreign Language—optional. |
| 3. Non-technical requirements—light. | 3. Non-technical requirements—20 per cent. |
| 4. Break at end of Sophomore year—none. | |

5. Degree—professional.
   M.S. 1 year.
   Professional Degree—undergraduate.

4. Very decided—students entering the Junior year must demonstrate:
   (a) scholastic ability.
   (b) comprehensive examination.
   (c) aptitudes for engineering work.
5. Degree—B.S. in Engineering
   M.S.—1 year.
   Professional Degree—5 years + Thesis.

ENGINEERING CURRICULA AT LEHIGH UNIVERSITY.




One representative from each department teaching subjects to engineers.

Elected.

ENGINEERING CURRICULA AT LEHIGH UNIVERSITY.

| | –1926 | 1926– |
|---|---|---|
| Pure Science | 25 per cent | 30 per cent |
| Applied Science | 59 per cent | 50 per cent |
| Non-technical | 16 per cent | 20 per cent |
| | 100 per cent | 100 per cent |
| Scholastic hours | 140 | 136 |

ENGINEERING CURRICULA AT LEHIGH UNIVERSITY.

| *First Semester.* | | *Second Semester.* | |
|---|---|---|---|
| Advanced Algebra | 3 | Plane Analytic Geometry | 3 |
| Chemistry | 2 | Qualitative Analysis | 3 |
| Chemical Laboratory | 2 | Stoichiometry | 1 |
| General Physics | 3 | General Physics | 3 |
| Physics Laboratory | 1 | Physics Laboratory | 1 |
| English | 3 | English | 3 |
| Mechanical Drawing | 2 | Descriptive Geometry | 2 |
| Military Science & Tactics | 2 | Military Science & Tactics | 2 |
| *Engineering Conference | | *Engineering Conference | |
| Physical Education | | Physical Education | |
| Chapel | | Chapel | |
| College Lectures | | College Lectures | |
| | 18 | | 18 |

Summer Term: C.E.s take Land and Topographical Surveying (4) and Railroad Surveying (2).

M.E.s, Met.s, E.M.s, E.E.s, Ind. Eng., Eng. Phy. } Land and Topographical Surveying (4).

Chem., Chem. Eng. } No work called for.

As a means of determining the aptitudes of the students for engineering work, and as a partial measure of the advisability of their continuing beyond the Sophomore year, it is proposed to rule the reverse side of the class record cards as indicated on the following chart, and have instructors enter their appraisal thereon.

ENGINEERING CURRICULA AT LEHIGH UNIVERSITY.

| | | | | | |
|---|---|---|---|---|---|
| Ability to think... | Very keen | Keen | Mediocre | Dull | Hopeless |
| Accuracy..... | Exceptional | Accurate | Fair | Careless | Hopeless |
| Industry..... | Very industrious | Industrious | Passable | Lazy | Hopeless |
| Interest†..... | Enthusiastic | Interested | Lukewarm | Lacks interest | Dislikes subject |

* Given once a week through Freshman and Sophomore years.

† In the subject you teach.

## Supplementary.

As a supplement to this report the following items are given:

*a.* Suggested procedure as outlined by President Richards.
*b.* Reaction of the Engineering Council to this suggested procedure.
*c.* Details of the engineering curricula adopted.
*d.* Requirements for the professional engineering degree.
*e.* Preliminary announcement of the revised engineering curricula.

### Suggested Procedure in the Consideration of Changes in the Curricula of the College of Engineering.

Before making any radical changes in the engineering curricula, it seems to me that it is desirable to consider the following questions and to reach an agreement concerning them.

1. What is the principal purpose of the engineering curricula at Lehigh University?

*a.* Should they undertake to lay a broad foundation in pure and applied science, in economics and the humanities, for a professional career?

*b.* Should we prepare men who are primarily technicians and who will follow engineering as a vocation?

*c.* Should we emphasize the importance of the service which an engineer may render to society, or frankly and avowedly train men with the sole idea of making money?

2. Assuming that for the present the time has not come when the period of training of engineers can be increased beyond four years, what is the maximum number of credit hours we can reasonably demand for a baccalaureate degree in engineering, assuming that there is a serious effort made to adhere to the standard credit hour of three hours of effort for each hour of credit. When the maximum number of hours which can be reasonably demanded has been determined, will it be logical to permit deviations therefrom either upward or downward?

3. What is the purpose of requiring some form of summer work as a prerequisite for graduation?

*a.* As a first step in the extension of the requirements for graduation from an engineering curriculum, are we ready to include the requirement of attendance at one or two six weeks' summer sessions for graduation? Two such summer sessions would be equivalent to the addition of one full term to our requirements.

*b.* If we are not prepared to increase the requirements for the baccalaureate degree in engineering as a matter of University policy, is it logical to permit any of the curricula to have requirements of resident summer work?

*c.* Is it preferable to require two or three summers of practical employment to the requirement of formal resident summer study?

*d.* If as a matter of University educational policy it is preferable to demand one or two or three summers of practical employment to summer work done in residence, is it logical to give formal University credit for work over which the University has no jurisdiction.

4. Assuming that we have agreed upon an answer to question 1 and without regard to existing individual courses of study, how should the time required for the baccalaureate degree in engineering be distributed in a broad way among the mathematical and physical sciences, the humanities or non-technical subjects such as English, language, economics, psychology, etc., the principal engineering subject represented by the curriculum in which the student is enrolled, and other correlated engineering courses? This, I take it, is one of the most important and difficult questions to be settled in the consideration of this general question. In this connection it seems to me desirable that we reach some definite policy concerning free electives in the engineering curricula or of restricted electives—that is, of a group of optional courses. Many educators believe that some free electives should be permitted in order that students may be allowed to follow their own bent in the selection of some subjects which are not

considered as fundamental. My own experience with free electives leads me to favor the idea of restricted electives or options.

5. How much time should be devoted to physical education and to military science and tactics, and how much of this time should we be willing to accept as applicable to the requirements fixed for a degree? Obviously, a definite place in the curriculum must be made for physical education and for the basic work in M. S. T. It would seem desirable to provide an option in the third and fourth years between some subject or subjects and the advanced M. S. and T. courses to simplify the selection of the latter. It does not seem essential, however, that we count the full amount of credit received in M. S. and T. for graduation.

6. Assuming that answers to the foregoing questions have been agreed upon, it becomes possible to undertake the allocation of individual courses to one or another of the major divisions of knowledge set up in answering question 4. This process will doubtless be fraught with great difficulties and it may necessitate the abandonment of some courses of trivial value or the upward or downward revision in the content of others. It is my belief that every course offered should undertake to present fundamentals and to train students in logical methods of reasoning. I do not believe that highly specialized or descriptive courses have much value. I do believe, however, that every fundamental course should be taught with a view to its possible practical applications in order that the student's interest in the subject and belief in the value of the course will be stimulated.

7. Having set up our engineering curricula by some such logical procedure as that which has been outlined, what should be the future policy with respect to the degree or degrees granted upon the completion of these curricula?

*a.* With the exception of a very limited number of colleges the degree of Bachelor of Science in one or another division of engineering is normally given.

*b.* If we believe that it is possible by purely academic proc-

esses to prepare men for engineering work without a period of practical apprenticeship it would seem logical to continue the practice of giving professional degrees upon the completion of the several curricula.

*c.* If it seems desirable to abandon our present practice and give the degree of Bachelor of Science, are we ready to adopt the practice of some other institutions in awarding professional degrees to those of our graduates who after say five years of successful practical experience, a part of which has been in responsible charge of work, submit a suitable thesis after their professional record has been approved?

*d.* Assuming that we agree to confer the degree of Bachelor of Science as the baccalaureate degree with some provision such as indicated in (*c*) for awarding professional degrees, are we ready to agree that the degree of Master of Science, in one or another division of engineering shall be the only degree recognized upon the completion of not less than one year of resident graduate study?

I have no doubt that there will be many other questions which will arise in the consideration of the foregoing and which will need to be discussed at length and settled before a logical solution of our curriculum problems can be reached. I am inclined to think, however, that the foregoing represent the principal debatable questions.

In this whole consideration it seems to me vital that we regard the questions of curriculum building as University rather than departmental problems. Without doubt the department chiefly concerned with the particular curriculum should be free to allocate the time at its disposal to such courses as the department offers which seem best to fit the requirements of the case; but in the settlement of the broad general principles the department should not be given an entirely free hand.

### Ideas of Council.

1. The engineering curricula at Lehigh University shall give a fundamental training in pure and applied science, in economics and the humanities, for a professional career, and

the Institution shall emphasize the importance of the service which an engineer may render to society.

The University is not interested in preparing men who are primarily technicians and who will follow engineering as a vocation.

2. The maximum number of credit hours for all curricula shall be 136, exclusive of M. S. and T., Gymnasium, Chapel, summer schools, summer work, etc.

Having settled on the maximum number of credit hours, it is not logical to permit deviations therefrom either upward or downward.

3. Certain studies, such as Surveying and Assaying, can be given to best advantage in a concentrated summer course.

Summer employment (not under supervision), accompanied by a written report, is desirable.

It is not advisable to require two regular six-week summer sessions with the view of considering these equivalent to the addition of one full term.

It is advisable to require two summers of work of all engineering students. These should consist of two summers of employment, one required summer school and one summer of employment, or two required summer schools.

4. The time required for a baccalaureate degree in engineering shall be distributed about as follows: Pure science 30 per cent, applied science 50 per cent, non-technical studies 20 per cent.

Any electives which may be offered shall be so-called "restricted electives."

5. The status of M. S. and T. and Gymnasium will probably remain as at present with regard to requirements, etc.

6. (For details see individual curricula already submitted. While these curricula are more or less tentative, a study of them shows that the 136-hour schedule is workable.)

7. The degree of B.S. in Engineering should be given instead of the present professional degree. (See requirements for professional engineering degree following.)

### Requirements for Professional Engineering Degrees.

After June, 1930 Lehigh University will abandon the practice of granting professional degrees in engineering upon the completion of undergraduate curriculums and thereafter will confer only the degree of Bachelor of Science in Chemical Engineering, Civil Engineering, Electrical Engineering, Industrial Engineering, Mechanical Engineering, Metallurgical Engineering, Mining Engineering, and in Engineering Physics. The degree of Master of Science in any of the above divisions of engineering, following the degree of Bachelor of Science in the same division, will be conferred after one year of resident graduate study at the University and the completion of all requirements for the Master's degree.

Believing that professional engineers can not be trained by a purely academic process, and with the abandonment of the practice of granting professional degrees for undergraduate work, Lehigh University proposes hereafter to confer professional degrees, (Chemical Engineer, Civil Engineer, Electrical Engineer, Industrial Engineer, Mechanical Engineer, Metallurgical Engineer and Engineer of Mines), upon those of its own graduates who hold the degree of Bachelor of Science or Master of Science in the particular division of engineering in which the professional degree is sought and who have had not less than five years of acceptable professional experience after receiving the Bachelor's degree.

Not later than October 15th of the academic year in which a professional degree is sought a candidate for such a degree must file with the Dean of the University a letter announcing his candidacy which shall present an itemized statement of his professional study and experience, including dates, character of work and the degree of responsibility therefor, together with any other illuminating evidence of his professional qualifications, and the names of not less than five men who have personal knowledge of the candidate's work. Upon the acceptance by the Faculty of the experience of the candidate, and not later than December 1st in the academic year in which the degree is sought, he shall file with the head of the depart-

ment concerned an outline for a thesis which is demanded in partial fulfillment of the requirements for the degree. After the subject and outline of the thesis have been approved, the thesis must be completed and deposited with the head of the department not later than April 1st. If the thesis is finally approved by the Faculty, the candidate must present himself at the Commencement exercises in June to receive his degree.

The term "acceptable professional work" includes every kind of engineering experience, particularly that in enterprises for which the candidate was in responsible charge; it may also include contributions to technical literature, membership in professional and learned societies, engineering research, and the teaching of engineering subjects.

The thesis shall be in the form of a dissertation on any technical subject in which the applicant is interested and has expert knowledge. It may take the form of an analysis of some important engineering problem, the original design of an engineering structure, or the description of some engineering process devised by the author. It must be couched in correct English and be typewritten (double spaced) on sheets size $8\frac{1}{2}'' \times 11''$ with margins. The thesis will be bound and deposited in the University Library. It shall not be published by its author without the approval of the Faculty of the University.

Upon the acceptance of his professional experience the candidate must pay to the University an incidental fee of $50; and, upon the approval of his thesis, a graduation fee of $10.

## Preliminary Announcement of the Revised Engineering Curricula, Lehigh University, Bethlehem, Pennsylvania.

An intensive study of the problems of technical education and the changing needs of modern industry made by the Faculty of Lehigh University, led to the conclusion that in the engineering curricula of the University greater emphasis than heretofore should be placed upon the fundamentals of engi-

neering, including mathematics, physics, chemistry and theoretical and applied mechanics, and less emphasis upon the highly specialized details of engineering practice; and that the engineer must know something of the social sciences, that is, the sciences which deal with human relations, and be familiar with the methods of business organization and administration. In the hope, therefore, that its work may become a still more effective preparation for service to industry and for professional work in engineering, the various engineering curricula have been revised to increase the time devoted to fundamentals and to decrease that assigned to specialized technical instruction. In addition, these revisions include a substantial increase in non-technical subjects which are a part of the equipment of every well-educated man and which are now recognized as essential to the proper training of engineers because of their practical applications in industrial and business life.

Among the unique features of the new curricula the following should be noted:

(1) Provision is made for a uniform freshman year in the College of Engineering so that no student will be required to select his course of study until he is better prepared, after a year of college work, to choose wisely. The requirements in the sophomore year for the various curricula are similar although not entirely uniform. A student can, however, make a change from one curriculum to another at the close of his second year with little loss of time.

(2) The work of the first two years is fairly self-contained. It affords preparation for a career as a draftsman, an electrician, a surveyor, a shop foreman, or as an assistant in a chemical laboratory or plant, to those who for one reason or another are unable to complete their engineering training. Students who complete successfully the work of the first two years without conditions or failures and who then withdraw from the University will be given a certificate of work completed.

(3) At the close of the second year a comprehensive examination on the work of the first two years will be required and a student's admission to the Junior class will be based upon

(*a*) his scholastic record for the first two years; (*b*) the results of his comprehensive examination; and (*c*) his "aptitude" for engineering work as determined by his instructors' estimates of his ability to think and his interest in the subjects taken, and his accuracy and industry.

(4) Believing that an engineer cannot be trained by a purely academic process, the baccalaureate degree that will be awarded upon graduation, beginning with the Class of 1930, will be Bachelor of Science in the particular division of engineering that has been studied, such as B.Sc in Civil Engineering. The successful completion of one year of graduate study after graduation will lead to the degree of Master of Science in the particular division of engineering studied.

(5) Professional engineering degrees such as Civil Engineer (C.E.), Mechanical Engineer (M.E.), etc., will be awarded to the graduates of Lehigh University having the degree of Bachelor of Science in Civil Engineering, Bachelor of Science in Mechanical Engineering, etc., and who have had not less than five years of acceptable practical experience in responsible charge of work after graduation, and who submit a suitable thesis.

Beginning in September, 1926, students entering the College of Engineering as freshmen will be registered in the work of the Uniform Freshman Year and they will thereafter register in accordance with the following curriculum prescriptions. Members of the three upper classes will, however, continue the work of the curricula in which they are registered as described in the annual Register for 1925–1926, and upon graduation they will be awarded the degree named therein.

## NEW MEMBERS.

ATTWOOD, STEPHEN S., Assistant Professor of Electrical Engineering University of Michigan, Ann Arbor, Mich. Sponsors, A. H. Lovell, B. F. Bailey.

BERGMAN, ELMER O., Assistant Professor of Civil Engineering, University of Colorado, Boulder, Colo. Sponsors, H. S. Evans, C. L. Eckel.

CORCORAN, GEORGE F., Instructor in Electrical Engineering, University of Minnesota, Minneapolis, Minn. Sponsors, F. W. Springer, O. M. Leland.

DUDLEY, A. MANSFIELD, Engineering Supervisor of Development, Westinghouse E. & M. Co., East Pittsburgh, Pa. Sponsors, F. L. Bishop, H. E. Dyche.

GOW, ALEXANDER M., Instructor, School of Mines, University of Minnesota, Minneapolis, Minn. Sponsors, F. B. Rowley, O. M. Leland.

GUS, CHARLES E., Instructor in Mechanical Engineering, New York University, New York City. Sponsors, W. R. Bryans, E. G. Hooper.

HALLIDAY, WILLIAM R., Associate Professor of Mechanism, Stevens Institute of Technology, Hoboken, N. J. Sponsors, F. D. Furman, S. H. Lott.

JOHNSON, JESSE H., Associate Professor of Geology, Colorado School of Mines, Golden, Colo. Sponsors, L. S. Grant, M. F. Coolbaugh.

JORDAN, HENRY G., Professor of Electrical Engineering, Colorado Agricultural College, Fort Collins, Colo. Sponsors, C. A. Lory, E. B. House.

MCNEELY, JOHN K., Research Professor of Electrical Engineering, Iowa State College, Ames, Iowa. Sponsors, F. L. Bishop, J. Weber.

NICHOLAS, JOHN E., Instructor in Mechanical Engineering, University of Minnesota, Minneapolis, Minn. Sponsors, F. B. Rowley, O. M. Leland.

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REDDICK, HARRY W., Professor and Head, Department of Mathematics, Cooper Union, New York City. Sponsors, F. E. Foss, F. M. Hartman.

SEABURY, GEORGE T., Secretary, American Society of Civil Engineers, 33 West 39th Street, New York City. Sponsors, W. E. Wickenden, H. P. Hammond.

SILER, RODERICK W., Assistant Professor of Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. Sponsors, W. E. Brooke, O. M. Leland.

STETSON, GEORGE A., Professor of Heat Power Engineering, New York University, New York City. Sponsors, W. R. Bryan, E. G. Hooper.

TAYLOR, C. FAYETTE, Associate Professor of Aeronautics, Massachusetts Institute of Technology, Cambridge, Mass. Sponsors, D. C. Jackson, H. W. Tyler.

THOMAS, FREDERICK H., Superintendent, Machine Laboratories, University of Illinois, Urbana, Ill. Sponsors, B. W. Benedict, A. C. Willard.

VAWTER, JAMISON, Assistant Professor of Civil Engineering, University of Illinois, Urbana, Ill. Sponsors, W. C. Huntington, T. C. Shedd.

WAGNER, HERMAN A., Consulting Metallurgical Engineer, 63 East Adams Street, Chicago, Ill. Sponsors, G. M. Butler, J. C. Clark.

WELLS, EVERETT D., Instructor in Mathematics and Mechanics, University of Minnesota, Minneapolis, Minn. Sponsors, W. E. Brooke, O. M. Leland.

WEYL, CHARLES, Assistant Professor of Electrical Engineering, University of Pennsylvania, Philadelphia, Pa. Sponsors, H. Pender, C. E. Clewell.

WITMER, FRANCIS P., Director of Civil Engineering, University of Pennsylvania, Philadelphia, Pa. Sponsors, H. Pender, H. C. Berry.

GEIGER, I. W., Associate Professor of Analytical Chemistry, University of Minnesota, Minneapolis, Minn. Sponsors, E. P. Harding, O. M. Leland.

Total new members, 1926–27, 109

## CHANGE OF NAME OF THE SOCIETY.

To the Membership of the Society,

*Dear Sirs:*

A year ago in answer to the suggestion that the name of the Society for the Promotion of Engineering Education be changed, a ballot of the Council was taken which showed that the majority was in favor of shortening the name. At the meeting of the Society held at the State University of Iowa last June, a Committee was appointed to consider the various proposals as to what the name should be, if it were decided to change it, and was requested to report at the meeting at Orono, Me., next June.

In order to give the membership of the Society a chance to express its opinion, for or against the present or any proposed name, the members are requested to address the Chairman of the Committee (W. T. Magruder, Ohio State University, Columbus, O.), indicating their choice of names and stating their reasons for changing and choosing.

The following are the arguments for changing the present name:

1. It is too long, especially for use over the telephone.
2. The Society has outgrown its original intention of "Promoting" engineering education.
3. It is thought that emphasis should be put upon the membership rather than on their intentions or the cause for the formation of the Society.

The arguments against the change of name are:

1. That members and others are familiar with the name of the Society, and particularly with its initials.
2. It has done good service for 33 years, so why change for the sake of changing?

3. Will a new name be any better or more easily understood over the telephone?

Among the names suggested are:

(*a*) Society for the Promotion of Engineering Education (the present name).....S. P. E. E.
(*b*) The Society for Engineering Education.....S. E. E.
(*c*) The Society of Engineering Education.....S. E. E.
(*d*) The Society of Engineering Educators.....S. E. E.
(*e*) The Engineering Education Society.....E. E. S.
(*f*) Possibly others.

The Committee will be pleased to have the advice and suggestions of the membership on this subject.

H. W. TYLER, Cambridge, Mass.,
P. F. WALKER, Lawrence, Kans.,
W. T. MAGRUDER, Columbus, O.

## THE ENGLISH DEPARTMENT.

If English is to be a vital influence in the development of the engineering student, it must not be thought of as a succession of courses in composition or literature, even though these courses be correlated closely with the other elements in the curriculum. The correlation must go further. It is not enough that the teachers of these courses in English be concerned for the student's ability to express himself coherently and for his taste in choosing his books. Every member of the Faculty who comes in contact with him must appreciate that, if this prospective engineer cannot write and speak intelligibly and with the diction of an educated man, he is doomed to limited usefulness in his profession, and that if somehow he fail to learn the love of books, he is doomed to many a dreary hour and to find himself at last deprived of his rightful inheritance in the rich literature of his race. When every member of the teaching force comes to see that his students are ultimately to be judged in the world at large quite as much by the English they speak and by the books they read, as by their professional expertness, and when they are all ready to bear their responsibility in this matter, conditions are ripe for a new and more vital correlation of English as a developmental experience. That is the ideal toward which as engineering educators we must work.

The Committee on English has so long preached, in season and out of season, this doctrine of the mutual responsibility of all engaged in instructing our students for their habits of English usage, that it is hardly necessary to do more than restate our position. When violations of the decencies of English usage are noted in laboratory reports, blue books, and theses, when slovenly or ungrammatical speech in recitation or in conference hour is tactfully but consistently corrected by teachers of technical subjects, our students are going to develop the habits of expression of educated men. Only by

a whole hearted coöperation of effort on the part of teachers of English and teachers of other subjects can such habits be established. Every week, in a really live engineering college, should be a "Better English Week." The Committee on English is encouraged to find that there is a growing appreciation for the need of such coöperation. Interesting experiments are reported to us,—coöperative courses in which the assignments are made by instructors in technical fields, and the writing is done under the direction of instructors in English, recall systems which remit to the English departments for further instruction students guilty of glaring inaccuracy in their English, the appointment of English instructors as editorial advisers for graduate and advanced students in the preparation of their theses, agreement of faculty groups to hold their students to a definite standard of decent usage and to note regularly, to the best of their knowledge and ability, violations of this standard. If the ideal set forth in the Preliminary Report of the Board of Investigation for an integration of the work in English and of the other humanities with the technical features of the curriculum is accepted, new and still more efficient means of coöperation will no doubt be worked out in the future.

At the joint meeting of the Deans and the teachers of English, held last June at Iowa City, one very important extension of this ideal was developed in the discussion of the teaching of English Literature to engineering students. I remember quoting Professor Gierson as saying that the teaching of English Literature is largely a matter of exposing the student to the contagion of the teacher's enthusiasm. Fortunately or unfortunately, the student is inclined to depreciate and discount the enthusiasms of his English teachers for books. I suppose he suspects their motives as more or less mercenary; they are paid for being enthusiastic. But when incidentally he discovers one of his professors in some technical field an enthusiast for some book outside his own specialty, he is deeply impressed. The responsibility of all members of the Faculty in sharing with their students their love of

books and by suggestion from time to time stimulating the habit of intelligent and discriminating reading is beginning to be felt. Here is clearly one more way in which "English" —how vaguely we use the term—may become something more than a schedule of courses, assuming perhaps the value of a real formative influence in the growth of the student's soul.

Professor Clyde Parke of the University of Cincinnati in the discussion at the Iowa City meeting commented on this ideal of coöperation as follows:

"One of the most significant contributions your committee has made in the last year or two has been to crystallize a growing sentiment in favor of the constant check-up on the students' writing that leads to the formation of correct habits of expression, particularly if those habits are encouraged by the technical instructors as well as by the Teachers of English. It seems to me that the trend of the present discussion is to crystallize a similar sentiment in favor of the development of good reading habits, as well as good habits of expression. These are really not distinct things, for, as we all recognize, good habits of expression are greatly affected by one's reading habits. The student should be impressed by the notion that perhaps he is missing something if he is not engaged in forming regular habits of good reading, and that he is making a mistake to postpone the formatives of such habits. Cooperation between the technical instructors and English instructors will lead not only to the formation of correct habits of expression but will similarly create a strong sentiment in favor of good reading. It will increasingly bring to the engineering student the feeling that I am sure we all hope he will love, that he is to be not simply a professional man, but an educated man, and that he is entitled just as much to the zest of creative literary effort and to the humor interest of a literary background as any other educated man belonging to the other professions."

Here is clearly one of the problems of correlation suggested to us by the ideal of an integrated course so positively placed before us by the Preliminary Report of the Board. How can

English become a more effective influence in the development of the engineering student? Fortunately the answer does not concern the little company of English teachers alone; it suggests a mutual and common responsibility.

Correspondence is desired. Address J. Raleigh Nelson, Chairman of the Committee on English, 927 Forest Ave., Ann Arbor, Michigan.

## SECTIONS AND BRANCHES.

The **Colorado Branch** met at four o'clock, October 20, 1925, in Engineering Building No. 1. The meeting was primarily a "get-acquainted" party for the faculty and their families. Refreshments were served, followed by dancing and games, which provided entertainment until six o'clock.

The second meeting of the autumn quarter was held on December 9. The meeting was preceded by a beefsteak dinner, prepared by a committee of the faculty. Professor Charles A. Hutchinson demonstrated his versatility by acting as chief cook.

At this meeting Dean H. S. Evans spoke on the activities of the Conference of Deans and Administrative Officers held in Washington, D. C., November 18 and 19, and outlined the report adopted by the Conference. No action was taken on this report; the faculty decided to study the report thoroughly, and then to meet during the winter quarter to discuss recommendations and decide what measures should be put into practice.

WAINO S. NYLAND,
*Secretary.*

The organization meeting of the **Greater New York and Northern New Jersey Section** occurred at Columbia University on the afternoon and evening of January 22, 1927, with the very gratifying number of one hundred and twenty-five in attendance.

Among the prominent names of persons who have been influential in the S. P. E. E. and in Engineering Education who were present on this occasion were, Past Presidents C. F. Scott, A. M. Greene, Jr., and G. B. Pegram, Past Vice-Presidents J. P. Jackson and F. H. Constant, Treasurer W. O. Wiley, Jr., Director Wickenden, Associate Director H. P. Hammond, W. S. Rodman, Vice-President and Chairman

of Committee on Sections, J. A. L. Waddell, Consulting Engineer, President Parke R. Kolbe of The Brooklyn Polytechnic Institute, Director S. S. Edmunds of the Pratt Institute and numerous others.

The preliminary business session occurred in Room 402 of the Engineering Building at 3:00 P.M. when Dean Pegram was elected temporary chairman, and he appointed committees on Nominations and on Constitution.

The main event of the afternoon session was Mr. Wickenden's discussion of the first installment of the final report of the Board of Investigation and Coördination. Mr. Wickenden presented this report in his usual clear and convincing manner which was followed by a spirited and instructive discussion interspersed with searching questions and informative replies. This was followed by an inspection trip to the Engineering laboratories and especially to the new fourteen story physics building and the new chemistry building, both of which appear to be about the last word in arrangement and facilities.

At 6:30 P.M. the delegates assembled at the University Faculty Club for a very excellent dinner and social time.

Following the dinner the permanent organization was perfected and this followed closely the example set by the very successful New England Section. The Constitution and By-Laws consisted of two paragraphs which simply stated the name of the organization and that the officers should consist of a President and Secretary whose duties were the usual ones of such officers and to arrange for such meetings as should be desirable. Dean G. B. Pegram of Columbia University was elected President and Dean E. H. Rockwell of Rutgers was elected Secretary of the Section. Dean A. M. Greene, Jr., invited the Section to have its next meeting at Princeton University. The invitation was accepted and a vote passed that the Princeton meeting would be held sometime during the spring. The feeling was quite general that Princeton would be an ideal place for a spring meeting which is likely to have social attractions as well as many interests of an educational nature.

The after dinner program was as follows:

*General Introduction and Discussion.* C. F. Scott, Professor of Electrical Engineering, Yale University, Chairman of the Board of Investigation.

*What should be the Relationship of the Engineering Colleges to the Educational and Vocational Guidance of Secondary School Students?* Harry D. Kitson, Professor of Education, Teachers College, Columbia University; Albert A. Colston, Principal, Brooklyn Technical High School.

*Selective Tests for Engineering Students.* C. C. Brigham, Professor of Psychology, Princeton University.

*Do the Engineering Colleges of the Metropolitan Area Properly Capitalize the Possibilities of Their Environment?* E. F. Church, Jr., Professor of Mechanical Engineering, Polytechnic Institute of Brooklyn; Walter Rautenstrauch, Professor of Industrial Engineering, Columbia University.

*Comments on the New Section.* W. S. Rodman, Professor of Electrical Engineering, University of Virginia, Vice-President, Member of the Council and Chairman of Committee on Sections.

The very large attendance at both the afternoon and evening dinner meetings was particularly gratifying and indicative of the need for this Section in the Metropolitan district. Enthusiastic approval of this first meeting was heard from many sources and the unanimous adoption of the motion for a spring meeting at Princeton is a good omen for another successful meeting in the near future. It is hoped that opportunities for social features and outdoor relaxation may be enjoyed along with the more serious discussion of educational policy.

EDWARD H. ROCKWELL,
*Secretary.*

## COLLEGE NOTES.

**Nanyang University**, one of the oldest and best technical schools supported by the Chinese Government, celebrated its thirtieth anniversary in October. One of the most important and interesting events of the celebration was the engineering exhibit, the first of its kind ever held in China at which machinery of all kinds, manufactured by various factories all over the world, was displayed.

More than fifty firms were listed among the exhibitors and more than twenty could not exhibit because of lack of space. The exhibit was held beginning from October 10, the Chinese national holiday, to October 17, and the total number of visitors during this period was about one hundred thousand.

The ornamental lighting units for the College installed only a few days before the exhibition were supplied by the Westinghouse Electric and Manufacturing Company.